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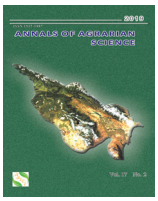

Georgia, the South Caucasus as the homeland of the hexaploid wheat

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A B S T R A C T

The importance of the local wheats of the South Caucasus for the evolution of the hexaploid wheat is largely overlooked. The South Caucasus and, especially, Georgia is the only country where all suitable conditions (on a very small territory are created for the origin of hexaploid wheat: 1) high diversity of local flora of wild and cultivated plants; 2) ancient Neolithic farming society confirmed by numerous archeological findings, which included nine species of wheat in Arukhlo and eight domesticated wheat species in each of Shulaveri and Khramis Didi Gora (southeast Georgia) dated as 8000 BP; 3) highest diversity and endemism of ancient hulled wheats represented with all seven hulled species; 4) highest diversity and endemism of free-threshing wheats; 5) presence of all tetraploid wheats - potential donors of AABB-genome; 6) presence of the of D-genome donor - all linages of *Aegilops tauschii* subsp. *strangulata* including the ancient, late flowering forms; 7) the presence of the endemic *T. timopheevii - T. zhukovskyi* lineage (AAGG-AAGGAA genomes); 8) The representation of the *T. turgidum – Tr. aestivum* lineage (AABB-AABBDD) genomes with two sub-linages: i) endemic hulled *T. turgidum* subsp. *palaeocolchicum – T. aestivum* subsp. *macha* and *ii*) free-threshing *T. turgidum* subsp. *carthlicum – T. aestivum*.

Keywords: Wheat, Domestication, Bexaploid wheat, Hulled wheat, Free-threshing wheat, Endemic.

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Introduction

The diversity of wheat species in Georgia, the South Caucasus is exceptionally high and Georgia exceeds in that countries of the Fertile Crescent which are widely recognized as the center of wheat domestication. Sinskaia [1] remarks that Front Asia, which includes Asia Minor, Near East, West Iran and the South Caucasus, is the native place of 12 wheat endemic species, out of which eight originated from the South Caucasus. The remaining four species originated from Syria, Palestine, Turkey and Iran - only one species per each country, respectively. Furthermore, out of the eight endemic species of the South Caucasus, five originated from Georgia. Georgia occupies the first place with richness in wheat species and forms on the earth [1].

According to the *sensu stricto* classification, fifteen species of wheat are identified in Georgia: *Triticum boeoticum* Boiss., *T. monococcum* L., *T. dicoccum* Schrank, *T. palaeocolchicum* Menabde, *T. timopheevii* (Zhuk.) Zhuk., *T. zhukovskyi* Menabde & Ericzjan, *T. carthlicum* Nevski, *T. durum* Desf., *T. turgidum* L., *T. turanicum* Jacubz., *T. polonicum* L., *T. macha* Dekapr. & Menabde, *T. spelta* L., *T. compactum* Host and *T. aestivum* L. [2-11]. The wheat species of Georgia are reviewed in Table 1. Most of the species are characterized by high infraspecific variation and are presented by 188 varieties in total [12].

It was noted that the wheat diversity of Georgia includes ancient, initial, relict species, as well as evolutionary advanced species and their inter-rela-

tionship shows all directions and transitional stages in the wheat evolution [5, 6, 8]. Georgia is the only country in the world where all genomes and ploidy levels of wheat (AA, AABB, AAGG, AABBDD and AAGGAA) are represented. The five species of wheat, which are endemic to Georgia, include four hulled species (*T. palaeocolchicum, T. macha, T. timopheevii* and *T. zhukovskyi*) and one free-threshing (*T. carthlicum*). At the same time, Georgia is the only country in the world where all 7 species of ancient hulled wheat are represented, including: 4 endemic and 3 non-endemic species (*T. monococcum, T. dicoccum* and *T. spelta*).

According to Nesbitt & Samuel [13] Agriculture in the South Caucasus has always been characterized by great diversity in the range of crops. This must be due in part to isolation of regions within the highly mountainous landscape. The same diversity is found in ancient plant remains [14]. However, the problem of poorly published data and lack of cultural context is perhaps greater for these areas to the north of the Near East than anywhere else: "… a fascinating variety of hulled wheats is grown, but we have nothing more than lists of plant species. We know virtually nothing of how the hulled wheats were used nor how their cultivation changed through time and came to cease"[13].

The present publication is an attempt to underline importance of the Georgian endemic wheat species for understanding of the wheat evolution through consideration of the agricultural history and biodiversity of Georgia, as well as summarize major findings of archeologists and wheat scientists, which emphasize importance of the area of Georgia for wheat domestication.

Table. *The wheat species of Georgia classified according to Sensu stricto [11] and sensu lato [43] classifications*

Wheat taxonomy (Ploidy / Genome)	
Sensu stricto classification	Sensu lato classification
Traditional [11]	Genetic [43]
Diploid (2n=14), AA, Wild, Hulled	
T. boeoticum Boiss.	*T. monococcum* subsp. *aegilopoides* (Link) Thell.
Diploid (2n=14), AA Domesticated, Hulled	
T. monococcum L.	*T. monococcum* L. subsp. *monococcum*
Tetraploid (2n=28), AABB, Domesticated Hulled	
T. *dicoccum* Schrank ex Schübl.	*T. turgidum* subsp. *dicoccum* (Schrank ex Schübl.) Thell.
● *T. palaeocolchicum* Menabde (*T. karamyschevii* Nevski)*	● *T. turgidum* subsp. *georgicum* (Dekapr. & Menabde) Mackey ex Hanelt
Tetraploid (2n=28), AABB Domesticated, Free-threshing	
● *T. carthlicum* Nevski	● *T. turgidum* subsp. *carthlicum* (Nevski)) Á. & D. Löve
T. durum Desf.	*T. turgidum* subsp. *durum* (Desf.) Husn.
T. turgidum L.	*T. turgidum* L. subsp. *turgidum*
T. polonicum L.	*T. turgidum* subsp. *polonicum* (L.) Thell.
T. turanicum Jacubz.	*T. turgidum* subsp. *turanicum* (Jakubz.) Á. & D. Löve
Tetraploid (2n=28), AAGG Domesticated, Hulled	
● *T. timopheevii* (Zhuk.) Zhuk.	● *T. timopheevii* (Zhuk.) Zhuk. subsp. *timopheevii*
Hexaploid (2n=42), AAGGAA Domesticated, Hulled	
● *T. zhukovskyi* Menabde & Ericzjan	● *T. zhukovskyi* Menabde & Ericzjan
Hexaploid (2n=42), AABBDD Domesticated, Hulled	
●*T. macha* Dekapr. & Menabde	● *T. aestivum* L. subsp. *macha* (Dekapr. & Menabde) Mackey
T. spelta L.	*T. aestivum* L. subsp. *spelta* (L.) Thell.
Hexaploid (2n=42), AABBDD Domesticated, Free-threshing	
T. compactum Host	*T. aestivum* subsp. *compactum* (Host) Mackey
T. aestivum L.	*T. aestivum* L. subsp. *aestivum*

Higher Plant Diversity and Agrobiodiversity in Georgia

According to Vavilov [2] centers of plant domestication are characterized by 1) high diversity of plants in the local flora that are suitable for domestication and 2) existence of old farming civilization. Both applies to Georgia.

The Caucasus region is ranked among the 36 most important global biodiversity hotspots [15]. The importance of the western Caucasus, especially the Colchis region, should be emphasized as it was a refugium during the glaciation where, among others, Neogene relict species survived [16-20].

The Caucasus biodiversity hotspot covers an area of more than 500,000 km^2 between the Caspian Sea and the Black Sea. The vegetation of the Caucasus is remarkably diverse, ranging from alpine meadows and mountain conifer forests to arid shrub-lands and semi-deserts. Of about 6,300 species of vascular plants, ca. 1,600 are endemic to the region. Georgia is a small country with total area of 69,000 km^2. It covers only 14% of the Caucasus territory. However, its vascular flora includes 4,150 species, which is 65% of all vascular plants of the Caucasus species. It is characterized by high endemism: 900 species (21%) found in Georgia are local endemics.

More than 2 000 species of the Georgian flora have direct economic importance for food, timber, edible fruits and nuts, forage and fodder, medicine, colorants, industry and essential oil production. In addition, there are many farmer-selected varieties and wild relatives of cultivated plants. A variety of crops, such as cereals (wheat, barley, rye, sorghum, millet), legumes (faba bean, grass pea, chickpea, lentil, cowpea), also flax, onion, garlic, and various fruits (grape, apple, pear, quince, medlar, peach, apricot, plum, cherry, cornelian cherry etc.) have been cultivated here since ancient times [21].

Evidences of existence of ancient gricultural civilization in Georgia

The Neolithic revolution in the South Caucasus could have begun as early as the 8th millennium BC (10 000 BP). The earliest a ceramic (lacking pottery) Neolithic sites in Georgia are mainly found in West Georgia, on the Black Sea coast and in the Colchis lowland.

One of the sites describing the dawn of the farming society in Georgia is cave 'Kotias Klde', which is found in the Kvirila River basin in West Georgia [22, 23]. Archeologists identified four cultural layers beneath the cave ranging from the Upper Paleolithic to the Bronze Age. A series of radiocarbon dates indicates a time range of the 11th to 9th millennia BC (10,850–8,240 BC) for 'Layer B' (Mesolithic) and 8th millennium BC (7,690–7,300 BC) for 'Layer A2' (Early Neolithic) [24]. The end of the Mesolithic period in Georgia, according to the archaeological records, was characterized by a number of innovations: tool production by means of scrubbing and polishing hard rocks, or by means of a macrolithic technique (bilateral slicing), the new shapes of tools, and the advent of pottery production. Along with the diversity of tools, the remains of various domesticated plants such as cereals, legumes, oil-fiber crops, grape, etc. bear witness to the high level of farming in the Neolithic period [26, 27].

By and large, macrofossil remains of crops cultivated by the Neolithic people of Georgia were the same as those 'founder' crops of the Fertile Crescent and Levant [27-29]. These included einkorn, emmer, bread wheat, barley, oats, rye, millet, grapes and various legumes [25-27].

Purported finds of endemic wheat species (*Triticum carthlicum* and *T. macha*) at early agricultural sites in Georgia [30] might suggest that Neolithic settlements in this region were sited to take advantage of wild cereal stands [31]. There is an opinion that wild wheat with dehiscent spikelets could have been cultivated for over one millennium before the emergence of domestic varieties with indehiscent spikelets. The reason is that early farmers had to harvest wild wheats before the spikelets fell to avoid loss, so indehiscent mutants that paved a way for domestic wheat were not easy to identify. Furthermore, when crops failed, farmers would have had to gather from the wild. These two practices lowered the probability of the rare indehiscent mutant being selected and prolonged the domestication period [32].

In Georgia, relic tools used to collect ancient hulled wheat spikes with brittle (fragile) rachis have survived to present. This is a woody tool, known as 'Snakvi' (Fig.1-a) originally created for wheat, and a stone mortar for dehusking (peeling) of ears of hulled wheat: makha, zanduri & asli. The method of collecting these crops with brittle rachis is very original in Georgia: the ears were cut into baskets with wooden scissors – 'Shnakvi' and the straw was collected with sickles. This method of collecting makha and zanduri wheat was used in the province of Lechhumi until the 1970s and 1980s.

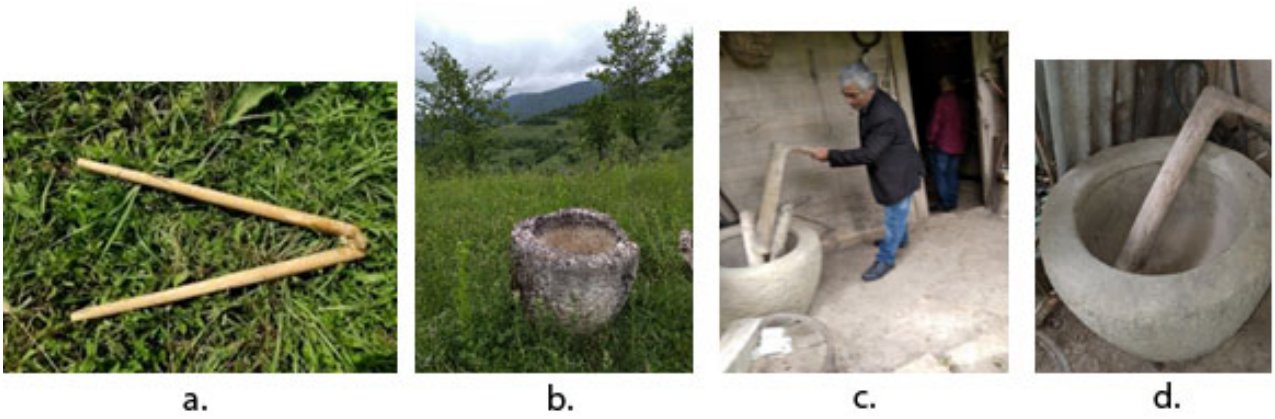

Fig. "*Snakvi" - the oldest tool for harvesting ears (spike) of hulled wheat species of "makha" "zanduli" and "asli" and b. Stony mortar, for dehusking hulled wheat spikes and spikelets; c, d.* Pestles in a mortar, a heavy woody tool with a rounded end, used for crushing and grinding tools for dehusking hulled wheat: makha, zanduri & asli.

Georgia is the homeland of viticulture and viniculture. The oldest domesticated grape (*Vitis vinifera*) pips and fermented wine were found by archeological excavations of 8000 BP in Shulaveri and Khramis Didi Gora in Kvemo Kartli Region (south-east Georgia). Chemical analyses of ancient organic compounds absorbed into the pottery fabrics from sites in Georgia in the South Caucasus region, dating to the early Neolithic period (ca. 6,000–5,000 BC), provide the earliest biomolecular archaeological evidence for grape wine and viniculture from the Near East, at ca. 6,000–5,800 BC. The discovery of early sixth millennium BC grape wine in this region is crucial to the later history of wine in Europe and the rest of the world [33].

In the 7th millennium BC a Neolithic culture known as the 'Shulaveri – Shomu' Culture appeared [34] and it diffused widely in the 6th millennium BC in the over what is now East Georgia, but mainly in Kvemo (Lower) Kartli. The archeological study of two sites Khramis Didi Gora and Arukhlo provided rich data on the 'Shulaveri – Shomu' Culture. It is known to be characterized by permanent settlements, circular vaulted mud-brick houses and farm buildings, tools made of obsidian, stone, bone and horn, female figurines reflecting fertility beliefs or clay vessels decorated with relief and notched ornaments. Production of cattle, pigs, wheat and barley was widely spread [35, 36].

Carbonized wheat grains discovered at archeological sites of Arkhulo, Khramis Didi Gora and Shulaveri of the 'Shulaveri – Shomu' Culture are dated back to the 6th millennium BC. Based on the analysis of these findings, archeologists and paleobotanists concluded that:

a) In late 7th and beginning of the 6th millennia, crop production was rather developed in Arkhulo, Khramis Didi Gora, Shulaveri (southeast Georgia) and wheat was cultivated alongside with other crops such as barley (*Hordeum vulgare and H. distichum*), oat (*Avena sativa*), rye (*Secale cereale*) and millet (*Panicum sativum*) in Khramis Didi Gora [28]. Legumes such as lentils (*Lens esculenta*), peas (*Pisum sativum*) and beans (*Vicia*) were also present in the South Caucasus [37].
b) During the Neolithic period (at archeological sites of Arkhulo, Khramis Didi Gora, and Shulaveri of the 'Shulaveri – Shomu' Culture (dated back to the 6th millennium BC) local farmers cultivated a large diversity of wheat, which included eight domesticated species: *Triticum monococcum, T. diccoccum, T. turgidum, T. carthlicum T. durum,T. spelta, T. aestivum, T. compactum,*
c) The South Caucasus was more diverse in terms of the wheat diversity than South Anatolia and Mesopotamia. This became evident when the Shulaveri-Shomu complex was compared to its contemporary sites in northern Mesopotamia (the Halaf and Hassuna cultures) and Anatolia (Hacilar) [34]. Archeological investigations of the Anatolian and Mesopotamian Neolithic sites provided evidence of existence of one, two or maximum three species of domesticated wheat [38, 39, 35]. As well as the cereals cultivated in the South Caucasus are much more diverse than in Anatolia and Mesopotamia [34].
d) Domesticated species largely prevailed over

wild species in the South Caucasus. *Triticum baeoticum* was the only wild species presented in Arukhlo.

e) The earliest appearance of naked tetraploid wheat species of *T. carthlicum* and *T. durum* is associated with the oldest layers of Arukhlo (i.e. late 7th and beginning of the 6th millennia) [25].

f) In contrast to the South Anatolian and Mesopotamian sites, naked free-threshing wheats dominated over hulled species in the early Neolithic period in Arukhlo. The Neolithic archaeological monuments of Arkhulo, Khramis Didi Gora, Shulaveri (south east Georgia) and Chikhori (west Georgia) are characterized by dominance of free-threshing (naked) *T. aestivo-compactum* type wheat. Based on the analysis of archeological and paleo-botanical data, it was estimated that the share of the *T. aestivo-compactum* type plants naked wheat was about 50-75 % of the total population of wheat. The 2nd most abundant wheat species in the Lower Kartli Neolithic sites was found to be emmer wheat (*T. dicoccum*). Its share was between 25% and 31%. Production of emmer declined over time and became less common in Bronze (ca. 3000 BC) and Iron [25, 40, 41].

Based on the above-mentioned facts, we can argue that agriculture was well-developed and high diversity of wheat (both hulled and naked) was cultivated in Georgia in late 7th and beginning of the 6th millennia BC (8000 BP). So, we can suggest that wheat domestication could have started at least at the beginning of the 7th millennium BC (9000 BP) in Georgia.

The possible role of the endemics of Georgia in the origin of cultivated hexaploid wheat

There are two polyploid lineages in *Triticum* genus: a) *T. timopheevii* - *T. zhukovskyi* lineage with AAGGAA-genome and b) *T. turgidum – Tr. aestivum* lineage with AABBDD-genome.

The AAGGAA-genome lineage has limited distribution and both tetraploid (*T. timopheevii*) and hexaploid (*T. zhukovskyi*) members of the linage are endemic to West Georgia, the South Caucasus [42]. Together with diploid *T. monococcum* (AA) they grow in admixtures forming local landrace "Zanduri".

The *T. turgidum – Tr. aestivum* lineage has much wider distribution covering the whole West Asia. However, three species (*sensu stricto*) out of this linage were apparently domesticated in Georgia and are considered as local endemics: *T. paleocolchicum, T. carthlicum*, and *T. macha.* In this paper, we would like to draw the reader's attention to the latter two species, which are distinguished with exceptionally high intraspecific variability. They are presented by 12 and 14 varieties, respectively [12].

T. macha a hulled hexaploid (AABBDD) wheat species endemic to Georgia was described by Dekaprelevich and Menabde in 1932 from prov. Lechkhumi (west Georgia) with 14 [12][1] varieties. This species always grows in admixture with another endemic hulled but tetraploid AABB genome species *T. palaeocolchicum.*

T. carthlicum, a free-threshing tetraploid Karthlian[2] wheat (erroneously named as Persianwheat)[3] is considered as a subspecies of *T. turgidum* by modern *sensu lato* classifications: *Triticum turgidum* subsp. *carthlicum* (Neyski) Á. Löve & D. Löve (syn. *T. persicum* Vav.). This wheat has been cultivated for at least 8000 years in Georgia according to the data of the Neolithic archeological excavations [25]. Out of the eleven varieties identified within *T. carthlicum*, all eleven were found only in Georgia and only one out of the eleven extended its areal to adjacent Armenia [43]. According to Matsuoka [42] *T. carthlicum* is strikingly similar to *T. aestivum* in morphology.

Karthlian wheat's spike morphology resembles more the morphology of common wheat (*T. aestivum*) rather than that of other subspecies of free-threshing tetraploid wheat [44]. Moreover, Kihara *et al*. [45] showed that the morphology of synthetic hexaploid wheat derived from crosses between subsp. *carthlicum* and *Aegilops tauschii* Coss., resembles that of common wheat and considered subsp. *carthlicum* as a candidate for the AB-genome donor of common wheat [44].

Wheat breeders noted that it was easy to transfer genes from Karthlian wheat to hexaploid bread wheat and it was suggested to be a very desirable donor because of many beneficial traits, such as good resistance to powdery mildew dust brand and stem rust, higher number of tillers and fertility, good

1. 14 varieties are described in the works of L. Dekaprelevich and Menabde, but only 12 are conserved in seed genebanks at present.
2. Karthli – a province in East Georgia.
3. Endemic to Georgia, never grown in Persia, erroneously named as Persian wheat by N. Vavilov.

fecundity, tolerance to low temperature and preharvest sprouting [46-55].

Despite the striking similarity of Karthlian and bread wheat, it was widely believed that allohexaploid common wheat (AABBDD genome) was derived from a natural hybrid cross between a cultivated form of hulled tetraploid *T. turgidum* (female parent) and the wild species *Ae. tauschii* (male parent) and that common wheat originated in the Middle East/South Caucasus ca. 8000 years ago. The nascent wheat of this hybridization was spelt, which had hulled and narrow grain, similar to emmer, from which free-threshing wheat evolved by mutations [56-59].

Accordingly, it was assumed that free-threshing tetraploid wheats were derived through hybridization between free-threshing hexaploid wheat and hulled tetraploid wheat. E.g. free-threshing Karthlian wheat was considered as a secondary species derived from an interspecific cross between hulled emmer and free-threshing common wheat [2, 42]. Kuckuck [60] found hexaploid wheat accessions showing the subsp. *carthlicum*-like morphology, and these accessions, called *T. aestivum* subsp. *carthlicoides* nom. nud., were distributed in the border region of Iran, Turkey and the South Caucasus. He proposed that subspecies c*arthlicum* originated from spontaneous hybridization between subsp. *carthlicoides* and cultivated emmer wheat *T. turgidum* subsp. *dicoccon* (Schrank) Thell [60].

However, this hypothesis contradicted with more recent archeological findings. Free-threshing hexaploid wheat seems to precede spelt in some archaeological records [13]. The oldest remnants of non-hulled grains identified as hexaploid wheat come from Anatolia and are dated to the middle of the 7th millennium BC [56, 61], whereas the oldest remnants of spelt came from the South Caucasus and Kurdistan and are dated to the fifth millennium [62, 63].

Dvorak *et al*. [64] proposed that a fee-threshing tetraploid wheat, not a hulled tetraploid was the A and B donor for the hexaploid wheat. The authors assumed that if the hypothesis of evolvement of free-threshing wheat from spelt through mutations was right and if free-threshing tetraploid wheats originated later through hybridization of free-threshing hexapliod and hulled tetraploid wheats, the resulting nascent free-threshing tetraploid should have D-genome germplasm fragments in its genome. The authors searched for D-genome germplasm in fourteen *T. turgidum* subsp. *carthlicum* accessions with 29 RFLP loci evenly distributed across the D genome failed to reveal any D-genome germplasm in the genome of *T. turgidum* subsp. *carthlicum* [64].

Assuming a free-threshing tetraploid wheat as the donor of A and B genome was more logical because the roundish shape of seeds, which is characteristic of free-threshing hexaploid wheat, is controlled to a large extent by genes in the A and B genomes. It was shown by the shape of seeds in tetraploid *T. turgidum* subsp. *carthlicum*, that it is virtually indistinguishable from those of bread wheat [64].

According to Dvorak *et al.* [64] the descent of hexaploid wheat from free-threshing tetraploid wheat was also more consistent with the origin and distribution of the Q gene. The Q allele is essential for the square-head spike morphology of hexaploid wheat and its free-threshing. If Q originated only once, it could have originated either at the tetraploid or at the hexaploid level [65]. If it originated at the hexaploid level (spelt being ancestral), free-threshing hexaploid wheat would have to precede free-threshing tetraploid wheat and Q would have to migrate from hexaploid wheat to tetraploid wheat to become fixed in all free-threshing tetraploid lineages. If mutation of q into Q took place at the tetraploid level, the nascent hexaploid would have Q, which would be immediately fixed in the hexaploid population. It was suggested before that most free-threshing wheat in archaeological sites in western Asia was tetraploid [29].

Originally, *Triticum spelta* was known only from Europe. It was described by Linne (1753) from Germany. Because *Ae. tauschii* does not grow anywhere in Europe, initially, spelt was not considered as an ancestral form of hexaploid wheat [66, 67]. Later, *T. spelta* was discovered in Iran [11, 68, 69] and other places in Asia [67]. Spelt was discovered also in the South Caucasus [10, 70]. However, Blatter *et al.* [71] showed that European and Asian spelt had different origins and that European spelt did not derive from the hulled progenitors of bread wheat.

Tzevelev (72:167) considered that the South Caucasian and Middle Asian *Triticum spelta* specimens, which had been determined as subsp. *kuckuchianum* Gökgöl described from Iran be similar to *T. macha* or *T. aestivum*. [10] suggested that "the presence of great variety of *T. spelta* forms found in the South Caucasus makes it possible to consider the Transcaucasia as the home land of the first hexaploid wheat prototype, which can be west Georgian endemic wheat makha (*T. macha*)" [10]. Earlier the same author noted that from the South Caucasus the

first hexaploid wheat of the *T. spelta* type penetrated to Iran and other regions of Inner Asia, as well as to Europe [70].

Distribution of D-genome donor Aegilops taushii in the South Caucasus

It is widely believed that *Aegilops tauschii* originated in the South Caucasus [73, 74] and from there it dispersed eastwards to western China across northern Iran and Central Asia and southwestward to central Syria [75]. Origin of *Ae. tauschii* (and each of its two subspecies: subsp. *tauschii* and subsp. *strangulata*) took place in the Caucasus [74]. *Aegilops tauschii* with all linages (TauL1, TauL2, TauL3) including the D-genome donor *Aegilops tauschii* subsp. *strangulata*, with both linages (TauL2, TauL3) represented only in Georgia [59]. Chloroplast DNA of TauL1 and TauL2 diverged from the TauL3 lineage [76). TauL3 accessions are restricted only to Georgia [77].

Conclusion

The South Caucasus and, especially, Georgia is the only country where all suitable conditions (on a very small territory) have been created for the homeland of hexaploid wheat:

1) Ancient farming society and archeological findings provide evidence of cultivation of 8 species of domesticated hulled and free-threshing wheat, among them 4 species of hexaploid species (*T. aestivum, T. compactum, T. spelta, T. sphaerococcum*) in the Neolithic settlements (6th millennium BC) of southeast Georgia (Arukhlo, Shulaveri and Khramis Didi Gora in Kvemo [lower] Karthli Region).
2) The presence of both polyploid lineages of the genus *Triticum* only in Georgia: a) *T. timopheevii* - *T. zhukovskyi* lineage with AAGGAA-genome and b) *T. turgidum – Tr. aestivum* lineage with AABBDD-genome.
    a. The presence of "Zanduri"-landrace, admixture of three species of diploid AA (*T. monococcum*), endemic tetraploid AAGG (*T. timopheevii*), endemic hexaploid AAGGAA (*T. zhukovskyi*) only in Georgia.
    b. The presence of "Makha "landrace, admixture of hulled tetraploid AABB (*T. palaeocolchicum*), and hulled hexaploid AABBDD (*T. macha/ T. spelta*) only in Georgia.
    c. The presence of free-threshing polyploid lineage of diploid DD (*Ae. tauschii* subsp. *strangulata*), naked tetraploid AABB (*T. carthlicum*), naked hexaploid AABBDD (*T. aestivum/T. compactum*) in recent Georgia and in archaeological excavations of the 8000 BP in Arukhlo, Shulaveri, Khramis Didi Gora, in the same time that common wheat originated ca. 8000 years ago.
3) The highest diversity of ancient hulled wheat. All seven species of the ancient domesticated hulled wheat recognized in the world are found in Georgia.
4) The highest endemism of hulled tetraploid (*T. palaeocolchicum, T. timophevii*) and hexaploid wheat (*T. zhukovskyi; T. macha-spelta*).
5) The highest diversity of tetraploid AABB wheats including free-threshing tetraploids (*T. durum* (25 varieties) and *T. turgidum* (25 varieties).
6) The highest diversity and endemism of free-threshing tetraploid AABB *Triticum turgidum* subsp. *carthlicum* to Georgia, with the common name in Georgian "dika".
7) Origin of *Ae. tauschii* in the South Caucasus (Dudnikov, 2012); distribution of all linages of *Aegilops tauschii* subsp. *strangulata* including the ancestral sub-linages in Georgia [59] and the presence of ancient, late flowering forms of both subspecies (subsp. *tauschi* and subsp. *strangulata*) only in the South Caucasus [74].

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References

[1] E. L. Sinskaya, Historical Geography of Cultivated Flora, Leningrad, Kolos, 1969 (in Russian).
[2] N. I. Vavilov, Studies on the Origin of Cultivated Plants (in Russian), in: Trudi po Prikladnoi Botanike, Genetike i Selektsii, 1926. pp. 1-248 (in Russian).
[3] N. I. Vavilov, Origin and Geography of Cultivated Plants, Cambridge University Press, Cambridge, 1992.
[4] K. A. Flaksberger, Cereals: wheat, in Flora of cultivated plants (in Russian), E. V. Wulf,

Ed., Moscow and Leningrad (St. Petersburgh), 1935 (in Russian)

[5] L. L. Dekaprelevich, The role of Georgia in origination of Wheat, Bulletin of the Academy of Sciences of Georgian SSR, vol. 2, (1942a) 153-160 (in Georgian).

[6] L. L. Dekaprelevich, The role of Georgia in origination of Wheat., Bulletin of the Academy of Sciences of Georgian SSR, vol. 5 (1942b) 445-500 (in Georgian).

[7] L. L. Dekaprelevich, Species, variations and varieties of wheat in Georgia, in: Proceedings of Institute of Field Crop Production of Academy of Sciences of Georgian SSR, vol. 8 (1954) 3-58 (in Russian).

[8] V. L. Menabde, Wheats of Georgia (in Russian), Institute of Botany, Academy of Sciences of Georgian SSR. Publishing House of Academy of Sciences of Georgian SSR, 1948 (in Russian).

[9] P. M. Zhukovsky, Cultivated Plants and Their Relatives, Kolos, Leningrad, 1964 (in Russian).

[10] V. F. Dorofeev, Wheats of the Transcaucasus, in:Proceedings in Applied Botany, Genetics and Plant Breeding, vol. 47, 1972, pp. 3-206, 1972 (in Russian).

[11] A. A. Dorofeev, A. A. Filatenko, E. F. Migushova, H. Udachin and M. M. Jakubtsiner, Wheat, in: Flora of Cultivated Plants, vol. 1, V. F. Dorofeev and O. N. Korovina, Eds., Leningrad (St. Petersburgh), 1979 (in Russian).

[12] M. Mosulishvili, D. Bedoshvili and I. Maisaia, A consolidated list of Triticum species and varieties of Georgia to promote repatriation of local diversity from foreign genebanks, Annals of Agrarian Science, vol. 15 (2017) 61-70.

[13] M. Nesbitt and D. Samuel, From staple crop to extinction? The archaeology and history of hulled wheats, in: Hulled wheats. Promoting the conservation and use of underutilized and neglected crops 4. Proceedings of the 1st International Workshop on Hulled Wheats, Castelvecchio Pacoli, Tuscany (Italy), International Plant Genetic Resources Institute, 1996, pp. 41–100.

[14] K. Wasylikowa, M. Cârciumaru, E. Hajnalová, B. P. Hartyányi, G. A. Pashkevich and Z. V. Yanushevich, East-central Europe, in: Progress in Old World Palaeoethnobotany, W. v. Zeist, K. Wasylikowa and K. Behre, Eds., Rotterdam, Balkema, 1991, pp. 207-239.

[15] N. Zazanashvili, G. Sanadiradze, A. Bukhnikashvili, A. Kandaurov and D. Tarkhnishvili, Caucasus, in: Hotspots revisited, Earth's biologically richest and most endangered terrestrial ecoregions, R. A. Mittermaier, P. G. Gil, M. Hoffmann, J. Pilgrim, T. Brooks, C. G. Mittermaier, J. Lamoreux and G. A. da Fonseca, Eds., Sierra Madre, CEMEX/Agrupacion, 2004, pp. 148– 153.

[16] G. Hewitt, The genetic legacy of the Quaternary ice ages, Nature, vol. 405 (2000) 907-913.

[17] D. Tarkhnishvili, A. Gavashelishvili and L. Mumladze, Palaeoclimatic models help to understand current distribution of Caucasian forest species, Biological J. of the Linnean Society, vol. 105, No. 1 (2012) 231-248.

[18] D. Tarkhnishvili, Historical Biogeography of the Caucasus, Nova Publishers, New Yourk, 2014.

[19] F. Walther, P. Kijashko and B. Hausdorf, Redescription of Vertigo (Vertigo) nitidula (Mousson, 1876) (Gastropoda: Vertiginidae) from the Caucasus region,Zootaxa, vol. 3872, no. 1 (2014) 075-082.

[20] Z. Kikvidze and M. Ohsawa, Richness of Colchic vegetation: comparison between refugia of south-western and East Asia, BMC Ecology, vol. 1, no. 6 (2001) 1-10.

[21] D. Bedoshvili, G. Aleksidze, D. Magradze, M. Mosulishvili, A. Gulbani, T. Jinjikhadze and T. Barblishvili, National Report on the State of Plant Genetic Resources for Food and Agriculture in Georgia," Food and Agriculture Organization of the United Nations (FAO), Rome, 2008.

[22] T. Meshveliani, G. Bar-Oz, O. Bar-Yosef, A. Belfer-Cohen, E. Boaretto, N. Jakeli, I. Koridze and Z. Matskevich, Mesolithic hunters at Kotias Klde, Western Georgia, Paléorient, vol. 33 (2008) 47–58..

[23] G. Bar-Oz, A. Belfer-Cohen, T. Meshveliani, N. Jakeli, Z. Matskevich and O. Bar-Yosef, Bear in mind: bear hunting in the Mesolithic of the Southern Caucasus, the case of Kotias Klde rockshelter, western Georgia, Archaeology, Ethnology and Anthropology of Eurasia, vol. 37, no. 1 (2009) 15-24.

[24] C. Chataigner, R. Badalyan and M. Arimura, The Neolithic of the Caucasus, Oxford University Press, London, 2014.

[25] N. Rusishvili , Fossil Wheat from the territory of Georgia (in Georgian), Flora, Geobotany and Palaeobotany, vol. 1 (1988) (in Russian).

[26] L. Pruidze, I. Maisaia, S. Sikharulidze and M. Tavartkiladze, Georgia - the Ancient Cradle of Agriculture, Color Ltd, Tbilisi, 2016 (in Georgian).
[27] C. Chataigner, La Transcaucasie au Néolithique et au Chalcolithique [Transcaucasia during the Neolithic and Chalcolithic], vol. 624, Oxbow Books Oxford, UK, 1995.
[28] G. N. Lisitsyna and L. V. Prischepenko, Paleoetnobotanicheskie nakhodki Kavkaza i blizhnego Vostoka [Paleobotanical data from the Caucasus and the Near East], Nauka, Moscow, 1977 (in Russian).
[29] D. Zohary and M. Hopf, Domestication of plants in the old world: The Origin and Spread of Cultivated Plants in West Asia, Europe and the Nile Valley, 3rd ed., Univ Press, Oxford, UK, 2000.
[30] Z. V. Yanushevich and N. S. Rusishvili, Novye paleoetnobotanicheskie nakhodki na eneoliticheskom poselenii Arukhlo I., in: Chelovek i okruzhaiushchaia ego sreda: materialy po arkheologii Gruzii i Kavkaza (in Russian), T. Chubinishvili, Ed., Tbilisi, Metsniereba, 1984, pp. 21-33 (in Georgian).
[31] T. Kiguradze and A. Sagona, "On the origins of the Kura-Araxes cultural complex, in: Archaeology in the Borderlands: Investigations in Caucasia and Beyond, vol. 47, A. T. Smith and K. Rubinson, Eds., , Cotsen Institute of Archeology, Los Angeles, University of California, 2003, pp. 38-94.
[32] K. Tanno and G. Willcox, How fast was wild wheat domesticated?, Science, vol. 311, no. 5769, 2006, pp. 1886.
[33] P. McGovern, M. Jalabadze, S. Batiuk, M. P. Callahan, K. E. Smith, G. . R. Hall, E. Kvavadze, D. Maghradze, N. Rusishvili, L. Bouby, O. Failla, G. Cola, L. Mariani, E. Boaretto, R. Bacilieri, P. This, N. Wales and D. Lordkipanidze, Early Neolithic wine of Georgia in the South Caucasus, PNAS, vol. 114 , no. 48, 2017, pp. E10309-E10318,
[34] C. Hamon, From Neolithic to Chalcolithic in the Southern Caucasus: Economy and Macrolithic Implements from Shulaveri-Shomu sites of Kwemo-Kartli (Georgia), Paléorient, vol. 34 (2008) 85-135.
[35] N. Bregadze , Georgia as an Independent Center of Origin of Agriculture, Publishing House Samshoblo, Tbilisi, 2004 (in Georgian).
[36] M. Jalabadze, K. Esakia, N. Rusishvili, E. Kvavadze, I. Koridze, N. Shakulashvili and M. Tsereteli, Report on Archaeological work carried out on Gadachrili Gora in 2006- 2007), Dziebani, J. of the Archaeology, vol. 19 (2010) 17-24 (in Georgian)
[37] O. Lortkipanidze, Archäologie in Georgien : von der Altsteinzeit zum Mittelalter, Weinheim : VCH, Acta Humaniora, 1991.
[38] L. Dzidziguri, The oldest agriculture of the South Caucasus, the J. of the Centre for Archaeological Studies of the Georgian Academy of Sciences, vol. Supplements II (2000) 343 (in Georgian).
[39] M. Nesbitt, When and where did domesticated cereals first occur in southwest Asia?, in: The Dawn of Farming in the Near East, R. T. J. Cappeters and S. Bottema, Eds., Berlin, ex oriente, Studies in Early Near East, Production, Subsistance and Environment, 6, 1999, 2002 (113-132).
[40] K. Esakia and N. Rusishvili, Chikhori settlement according to paleoethnobotanical and trace data, J. of the Centre for Archaeological Studies of the Georgian Academy of Sciences, vol. 6 (2000) 13-15 (in Georgian).
[41] I. Maisaia, T. Shanshiashvili and N. Rusishvili, Crops of Colchis, Metsniereba, Tbilisi, 2005 (in Georgian).
[42] Y. Matsuoka, Evolution of polyploid triticum wheats under cultivation: the role of domestication, natural hybridization and allopolyploid speciation in their diversification, Plant and Cell Physiology, vol. 52, no. 2 (2011) 750–764.
[43] M. W. van Slageren, Wild Wheats: A monograph of Aegilops L. and Amblyopyrum (Jaub. & Spach) Eig (Poaceae), Agricultural University, Wageningen, 1994.
[44] S. Takumi and R. Morimoto, Implications of an inverted duplication in the wheat KN1-type homeobox gene Wknox1 for theorigin of Persian wheat, Genes & Genetic Systems, Vol. 90, no. 2 (2015) 115–120.
[45] H. Kihara, M. Okamoto, M. Ikegami, J. Tabushi, H. Suemoto and Y. Yamane, Morphology and fertility of the new synthetized hexaploid wheats. Report of Kihara Institute of Biological Research, Seiken Jiho, vol. 4 (1950) 127-140.
[46] G. Belay, A. Merker and T. Esemma, Cytogenetics studies in Ethiopean landraces of tetraploid wheat (Triticum turgidum L.) Spike morphology vs ploidy level abd karyomorphology,

Euphytica, vol. 121 (1994) 45-52.
[47] V. M. Raut, V. P. Patil and G. B. Deodikar, Genetic studies in tetraploid wheats. VII. Inheritance of seedling resistance againts stem rust races, Biovigyanam, vol. 10 (1984) 101-106.
[48] Z. V. Gol-Denberg, Content of protein and tryptopham in some species of wheat and rye and in wheat-rye amphiploids, Bulletin of Academy of Sciences of Georgian SSR, vol. 114 (1984) 373-376.
[49] K. Anamthawat-Johnson, Wide hybrids beetween wheat and lymegrass: Breeding and Agricultural Potential, Buvisindi ICEL Agricultural Science, vol. 9 (1996) 101-113.
[50] A. Merker and K. Lantai, Hybrids between wheats and perrenial Leymus and Thiopyrum species, Acta Agriculture Scandinavica Section B Soil and Plant Science, vol. 47 (1997) 48-51.
[51] H. N. Pandey and M. V. Rao, Grain improvement in Triticum durum through interspecific hybridization, Indian J. of Genetics and Plant Breeding, vol. 47 (1987) 133-135.
[52] F. De Moraes, M. A. Zanatta, A. M. Prestes, V. da Rosa Caetano, A. L. Barcellos, D. C. Angra and V. Pandolfi, Cytogenetics and immature embryo culture at Embrama Trigo breeding program: transfer of disease resistance from related species by artificial resynthesis of hexaploid wheat (Triticum aestivum L. em. Thell), Genetics and Molecular Biology, vol. 23 (2000) 1051-1062.
[53] C. H. Balatero and N. L. Darvey , Influence of selected wheat and rye genotypes on the direct synthesis of hexaploid triticale," *Euphytica,* vol. 66, pp. 179-185, 1993.
[54] R. V. De Pienaar and E. R. Sears, "Methods to improve the gene flow from rye and wheat to triticale, in: Proceeding of the 4th Inetrnational Wheat Genetics Simposium, Triticale, Columbia, 1973.
[55] P.-p. Zhuang, Q.-c. Ren, W. Li and G.-Y. Chen, Genetic Diversity o f Persian Wheat (Triticum turgidum ssp. carthlicum) Accessions by EST-SSR Markers, American J. of Biochemistry and Molecular Biology, vol. 1, no. 2 (2011) 223-230.
[56] G. C. Hillman, On the origins of domestic rye—Secale cereale: the finds from aceramic Can Hasan III in Turkey, Anatolian Studies, vol. 28 (1978) 157–174.
[57] H. Kihara, Discovery of the DD-analyser, one of the ancestors of Triticum vulgare, Agriculture and Horticulture, vol. 19 (1944) 13-14 (in Japanese).
[58] E. S. McFadden and E. R. Sears, The origin of Triticum spelta and its freethreshing hexaploid relatives, J. of Heredity, vol. 37 (1946) 81, 89, 107–116.
[59] Y. Matsuoka, S. Takumi and S. Nasuda, Genetic Mechanisms of Allopolyploid Speciation Through Hybrid Genome Doubling: Novel Insights from Wheat (Triticum and Aegilops) Studies, in: International Review of Cell and Molecular Biology, K. W. Jeon, Ed., Elsevier,vol. 309 (2014) 199-258.
[60] H. Kuckuck, "On the origin of Triticum carthlicum Nevski (=Triticum persicum VAV.), Wheat Information Service (electronic letter for wheat researchers), vol. 50 (1979) 1-5.
[61] D. de Moulins, Les restes de plantes carbonisées de Cafer Höyük,"Cahiers de l'Euphrate, vol. 7 (1993) 191-234 (in France).
[62] F. K. Bakhteyev and Z. V. Yanushevich, "Discoveries of cultivated plants in the early farming settlements of Yarem-Tepe I and Yarem Tepe II in northern Iraq, J. of Archaeological Science, vol. 7 (1980) 167–178, 1980.
[63] G. N. Lisitsyna, The Caucasus—a centre of ancient farming in Eurasia, in: Plants and ancient man: studies in palaeoethnobotany, W. van Zeist and W. A. Casperie, Eds., Rotterdam (the Netherlands), Balkema, 1984, pp. 285–292.
[64] J. Dvorak, K. R. Deal, M.-C. Luo, F. M. You, K. v. Borstel and H. Dehghani, The origin of spelt and free-threshing hexaploid wheat, J. of Heredity, vol. 103, no. 3 (2012) 426–441..
[65] K. J. Simons, J. P. Fellers, H. N. Trick, Z. C. Zhang, Y. S. Tai, B. S. Gill and J. D. Faris, Molecular characterization of the major wheat domestication gene Q, Genetics, vol. 172 (2006) 547-555.
[66] E. Schiemann, Emmer in Troja, Berichte der Deutschen Botanischen Gesellschaft, vol. 64 (1951) 155-170.
[67] J. Dvorak and M.-C. Luo, Evolution of free-threshing and hulled forms of Triticum aestivum: old problems and new tools, in: Wheat Taxonomy: the legacy of John Percival, P. Calgari and P. Brandham, Eds., Proceedings in 1999 in Redding (UK), The Linnean Society in London. Academic Press, London, 2001, pp. 127-136.
[68] H. Kuckuck and E. Schiemann, Über das Vor-

kommen von Spelz und Emmer (Triticum spelta L. und Tr. dicoccum Scübl.) im Iran, Zeitschrift für Pflanzenzüchtung, vol. 38 (1957) 383-396 (in German).

[69] H. Kuckuck, On the findings of Triticum spelta L. in Iran and on the arising of Trititicum aestivum-types through crossings of different Spelta-types, Wheat Information Service (electronic newsletter for wheat researchers), Vol. 9-10 (1959) 1-2.

[70] V. F. Dorofeev, Geographical localization and gene centers of hexaploid wheats in the Transcaucasia (in Russian), Genetika, vol. 3 (1966) 16-33 (in Russian).

[71] R. H. E. Blatter, . S. Jacomet and A. Schlumbaum, About the origin of European spelt (Triticum spelta L.): allelic differentiation of the HMW Glutenin B1-1 and A1-2 subunit genes, Theor Appl Genet, no. 108, (2004) 360-367.

[72] N. N. Tzvelev, Zlaki USSR (in Russian), Nauka, Moscow, 1976 (in Russian).

[73] K. Hammer, Vorarbeiten zur monographischen Darstellung von Wildpflanzensortimenten: Aegilops L., Kulturpflanze, vol. 28 (1980) 33–180.

[74] A. J. Dudnikov, Chloroplast DNA non-coding sequences variation in Aegilops tauschii Coss.: evolutionary history of the species, Genetic Resource and Crop Evolution, vol. 59 (2012) 683–699.

[75] Y. Matsuoka, S. Takumi and T. Kawahara, Intraspecific lineage divergence and its association with reproductive trait change during species range expansion in central Eurasian wild wheat Aegilops tauschii Coss. (Poaceae),"BMC Evolutionary Biology, vol. 15, no. 213 (2015).

[76] M. Gogniashvili, P. Naskidashvili, D. Bedoshvili, A. Kotorashvili, N. Kotaria and T. Beridze, Complete chloroplast DNA sequences of Zanduri wheat (Triticum spp.), Genetic Resources and Crop Evolution, 2015 (in Georgian).

[77] Y. Matsuoka, S. Nasuda, Y. Ashida, M. Nitta, H. Tsujimoto, S. Shigeo and T. Kawahara, Genetic Basis for Spontaneous Hybrid Genome Doubling during Allopolyploid Speciation of Common Wheat Shown by Natural Variation Analyses of the Paternal Species, PLOS|ONE, vol. 8, no. 8 (2013).

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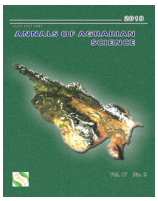

The opportunities of agritourism development in the Republic of Armenia

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A B S T R A C T

Agritourism is a type of vacation in which hospitality is offered on farms. The article discusses the essence of agritourism, presents some facts about tourism in Armenia. Some data about number of hotels, their employees and revenues, unemployment rate, average monthly wages and agricultural output in regions are discussed. In Armenia the main tours include some activities of agritourism, but there are not specialized agritourism, the number of agritourists and the sum of money they spend on tours are not available by statistics. To find out the main issues for agritourism development in Armenia, we have conducted SWOT analysis, which helped to explore strengths, weaknesses, opportunities and threats, and determine the strategy of advancement. Our analysis showed that the External factor evaluation and Internal factor evaluation scores were above average 2.5. Placing the weighted scores on SPACE Matrix, we got the best strategy quadrant, which is the aggressive strategy. Based on it some suggestions were made to promote agritourism. The model of agritourism impact on social-economic development was processed. Agritourism promotion is very important for Armenia, as it will contribute to regional economic development, social development, decrease immigration, etc.

Keywords: Agritourism, Rural community, Hotel facilities, SWOT, Aggressive strategy, Direct contribution.

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Introduction

Tourism develops very fast and is considered to be one of the leading sectors of world economy. Agritourism has an important place among the main types of tourism. It contributes to the development of rural places, to the increase of income in regions and villages, to the development of infrastructures, to the decrease of poverty and unemployment, etc. Agritourism, being a part of rural tourism, may be defined as the ‘’country experience’’ that encompasses a wide range of attractions and activities that take place in agricultural or non-urban areas. Its essential characteristics include wide-open spaces and opportunities for visitors to directly experience agricultural and natural environments [1].

The Republic of Armenia has 10 regions. Agritourism development is very crucial for Armenia. It may offer many interesting activities for tourists like participating at farm activities, harvesting, being in a rural place, etc. However there are many obstacles, that hinder agritourism advancement in Armenia. The aim of the article is to analyze the essence of agritourism, the possibilities and main issues of its development in Armenia and suggest solutions for that.

Literature review

Here we will briefly present some features of agritourism. Agritourism is the type of tourism when tourists take part in farm or village activities, such as animal and crop care, cooking and cleaning, handicrafts and entertainments [2]. According to Wicks and Merrett, agritourism “is a hybrid concept that merges elements of two complex industries - agriculture and travel/tourism - to open up new, profitable markets for farm products and services and provide travel experience for a large regional market [3]. According to Wall, agritourism is the provision of touristic opportunities on working farms [4].

Privateer states, that agritourism helps preserve rural lifestyles and landscape and also offers the opportunity to provide “sustainable” or “green” tourism [5].

According to Marques, agritourism is a specific type of rural tourism in which the hosting house must be integrated into an agricultural estate, inhabited by the proprietor, allowing visitors to take part in agricultural or complementary activities on the property [6].

Agritourism includes a range of activities, services and amenities provided by farmers and rural people to attract tourists to their area in order to generate extra income for their businesses [7].

Discussion

In Armenia tourism is announced as the main sector of economy. In 2018 1,651,782 tourists visited Armenia (10,5% growth compared to last year) [8].

In Armenia the direct contribution of Travel & Tourism to GDP was USD 477.7mn, 4.4% of total GDP in 2017, and the total contribution was USD 1719.7mn, 15.7% of GDP in 2017. In 2017 Travel & Tourism directly supported 44,500 jobs (3.9% of total employment), and the total contribution of Travel & Tourism to employment, including jobs indirectly supported by the industry was 14.1% of total employment (162,000 jobs). Visitor exports generated USD 1092.4mn, 29.2% of total exports in 2017. Travel & Tourism investment in 2017 was USD 108.9mn, 4.6% of total investment [9]. The travel subindex of the Balance of payments of Armenia was (-149.62 mn USD in 2017 (credit 1120.17 mn USD and debit 1269.80 mn USD) [10], this means that our incoming tourists spent less in Armenia than outgoing tourists abroad. If we divide the sum of credit on the number of incoming tourists, we will get 750 USD, this is the average sum that one tourist spends in Armenia.

The number of hotel facilities in Armenia was 556 in 2017, 320 or 58% of which were in the capital city Yerevan. So, the other 236 were in 10 regions, the most in Tavush, Kotayk, Syunik [11].

Armenia is rich in majestic mountains and plains, meadows, broad-leaved forests, botanic parks, plant and animal life. There are many agricultural festivals and farmer's fairs which attract tourists to Armenian villages. Every year festivals are organized in Armenia such as:

- ''Dolma'' festival in Musaler, Armavir region,
- ''Barbeque (khorovats)'' festival in Akhtala, Lori region,
- Wine festival in Areni, Vayots Dzor region,
- ''Gata'' festival in Khachik, Vayots Dzor region,
- "Traditions of Syunik" Festival in Goris, Syunik region,
- Festival "Cultural revival" in Dilijan, Tavush region [12].

Besides, agricultural food fairs are organized and citizens may buy fruits or vegetables from villagers.

In Armenia each urban and rural community consists of one or more settlements. There are 1002 settlements in Armenia, which are unified in 502 communities [13].

Total de jure population in Armenia is 2979.6 thousand people in Armenia, from which rural population counts 1080.8 thousand people [14]. Gross agricultural output by farms counted 907.5 bln AMD in 2016 in the RA (15.9% of the GDP of Armenia) [15], 97% of which was the output of household's plots [16]. At the same time unemployment rate in Armenia was 18%, very high in Kotayk and Shirak. Besides the average monthly nominal wage is the lowest in Aragatsotn and Shirak [11].

There are some tour agencies in Armenia, that include agritourism activities in their tours, such as participating in preparing national dishes or in the preparation of "lavash", the traditional Armenian flatbread, staying in farms, doing gardening with local people, gathering fruits, feeling the village life, etc.

However there is lack of statistical information about the number of agritourists, the sum of money they spend during a tour, and what activities they mostly prefer. Also there are many obstacles for agritourism development.

Agritourism development will contribute to regional development of the RA, as tourism:

- has a direct and total contribution to GDP,
- brings money from visitor expenses and has a multiplier effect,
- creates new jobs and contributes to poverty decrease,
- enables new investments and develops infrastructures,
- contributes to the maintenance of the environment and rational use of natural resources,
- contributes to the development of other sectors of the economy as well (trade and services, education, technologies, construction, agriculture, etc.).

Methods

The objective of the article is to reveal and analyze the main issues of agritourism development in Armenia based on the comprehensive research.

During the research the following methods were

used: analysis and synthesis, internal and external factor evaluation (SWOT - strengths, weaknesses, opportunities and threats) analysis.

The methodology of SWOT analysis is the following: After listing the key internal and external factors as strengths and weaknesses, opportunities and threats, we give each factor a weight that ranges from 0.0 (not important) to 1.0 (very important). The sum of all weights assigned to the factors must equal 1.0. Then we assign a rating between 1 and 4 to each key internal and external factor (rating =1 means that the factor is too weak and rating =4 means that the factor is major strength). By multiplying each factor's weight by its rating we determine a weighted score. After we sum the weighted scores for each variable to determine the total weighted score, the highest possible total weighted score is 4.0 and the lowest possible total weighted score is 1.0. The average total weighted score is 2.5 [17].

Findings

For conducting SWOT analysis we have explored strengths, weaknesses, opportunities and threats. All those factors are in the tables with the rating and weight scores.

Table 1. *Internal factor evaluation*

N	Factors of internal environment	Weight	Rating	Weighted score
Strengths				
1.	Agritourism assets in Armenia	0.08	4	0.32
2.	Rich historical and cultural heritage in all 10 regions	0.08	4	0.32
3.	Armenian wine and brandy, lavash and apricot are well known in the world	0.06	4	0.24
4.	Armenian big diaspora	0.06	4	0.24
5.	Great number of tourism agencies	0.06	3	0.18
6.	Each region in Armenia has national dishes	0.06	4	0.24
Total				1.54
Weaknesses				
1.	Low number of hotels in some regions	0.06	2	0.12
2.	Agritourism activities are included in classic tour packages and there are almost not specified agritours	0.08	3	0.24
3.	Low level of effectiveness of tourism marketing and branding for attracting international tourists	0.08	4	0.32
4.	There is no concept or strategic plans of agritourism development	0.08	4	0.32
5.	Not complete statistical recording of the sphere	0.08	4	0.32
6.	Not fully developed infrastructures	0.08	3	0.24
7.	Low level of current situation and conservation of the environment and natural resources	0.08	3	0.24
8.	Low level of staff training and a lack of skilled labor	0.06	3	0.18
Total				1.98
Total strengths and weaknesses		1	49	3.52

Thus, the total weighted score of strengths and weaknesses is 1.54+1.98=3.52
IFE (Internal factor evaluation) = 3.52

Afterwards, the factors of external environment were investigated by dividing them into opportunities and threats, which were rated from 1 to 4 and weighted from 0 to 1.

Table 2 . *External factor evaluation*

N	Factors of external environment	Weight	Rating	Weighted score
Opportunities				
1.	Implementation of marketing performance for increasing the number of domestic and incoming agritourists	0.121	4	0.485
2.	The possibility of developing tourism infrastructures	0.121	4	0.484
3.	Elaboration of development strategies	0.121	4	0.484
4.	Improvement of statistical recording of the sphere	0.121	4	0.484
5.	Processing and offering specialized agritours with a wide range of agricultural activities for incoming and domestic tourists	0.121	3	0.363
6.	Formation of a regional agritourism package with neighbors Georgia and Iran	0.091	2	0.182
Total				2.482
Threats				
1.	Unemployment and low income level of the population	0.121	3	0.363
2.	The possibilty of not good influence of not fully developed tourism infrastructures on the number of tourists	0.091	3	0.273
3.	Increasing immigration of population, especially in regions	0.091	3	0.273
Total				0.909
Total opportunities and threats		1.00	30	3.391

Thus, the total weighted score of opportunities and threats is 2.482+0.909=3.391
EFE (External factor evaluation) = 3.391

As we see, the EFE and IFE are above average 2.5. We have applied IE (internal-external) strategy space matrix to find out the best strategy based on our weighted scores. Our score is in the aggressive quadrant.

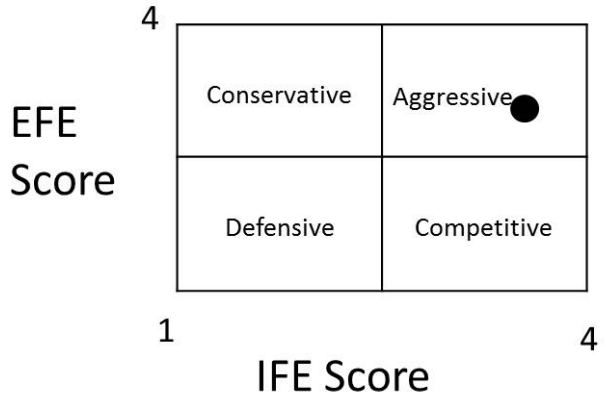

Fig. 1. *IE strategy space matrix*

Aggressive quadrant of the SPACE Matrix is an excellent position which means that the industry is attractive and stable, the competitive advantage is high. Thus, the position in aggressive quadrant requires taking advantage of external opportunities and overcoming internal weaknesses, trying to minimize threats by using internal strengths. Also, aggressive strategy means to penetrate new markets, or develop the share in existing markets, develop tourism product by using innovations. Therefore, the formation of the strategy should solve these issues by having as a basic goal the increase of social-economic conditions in regions, which main elements are shown in the following model, presenting the impact of agritourism development on economy (figure 2).

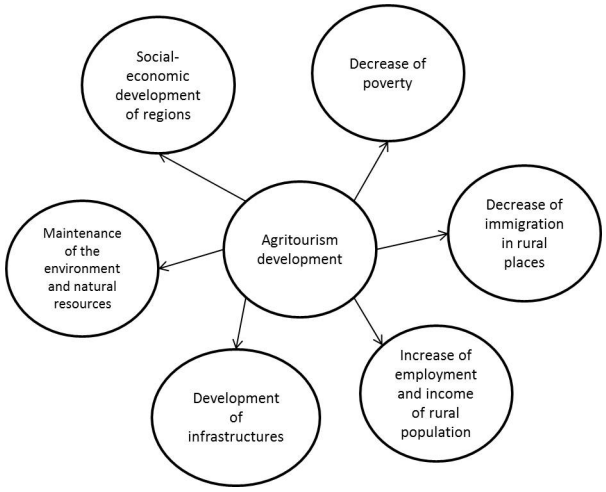

Fig. 2. *Main impact of agritourism development**

**The figure was processed by the author.*

Conclusion

The conducted analysis in the article shows that Armenia has great opportunities to promote agritourism. Agritourism development will contribute to the advancement of rural areas and regions as well. Armenia is rich in historical, cultural, religious monuments, resort resources, and tourists, while visiting to historical, cultural monuments in the regions of Armenia, are likely to stay at rural places. However, offering specialized agritours with a wide range of agricultural activities is very crucial. Armenian hospitality and rich cuisine may also have a deep impact on agritourism development, as tourists like to taste agricultural food and dishes at rural places, and also participate to the preparation process. Agritourism is considered to be a kind of cheap rest, as hotel facilities (especially B&Bs) in regions cost less. Besides, fresh air and climate, nature and healthy food in Armenia are very attractive factors.

The conducted analysis makes it possible to do some suggestions. First of all it is of high importance to process and implement strategic programs for development of agritourism industry in the RA (aggressive strategy, having as basic goals the model proposed by us).

As now tourism agencies offer inclusive tours which include also some agritourism activities, it is very important to process agritours, developing main routes and plan of activities for few days (from 3 to 7 days).

The marketing policy of tourism should also be aggressive by using a large set of marketing tools (also e-marketing) presenting the country's agritourism assets, agricultural festivals, rich agricultural products and rural hospitality abroad and in the country for attracting not only international but also domestic tourists.

It is of high necessity to organize trainings and workshops for farmers who offer agritourism activities according to international practice. The above mentioned steps will help to advance agritourism in Armenia.

References

[1] I. Humaira, Rural tourism – an overview, 2010, http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/csi13476/$FILE/Rural- Tourism.pdf (accessed 13.03.18).

[2] Agritourism, Dictionary, http://www.dictionary.com/browse/agritourism (accessed 13.03.18).

[3] B. E. Wicks & C. D. Merrett. Illinois Institute for Rural Affairs, Agritourism: An economic opportunity for Illinois, Rural Research Report, Vol.14, No.9 (2003) 1-8.
[4] G. Wall. Agrotourism. In J. Jafari (Ed.), Ency clopaedia of Tourism, Routledge ,London, 2000.
[5] D. Privitera,The İmportance of Organic Agriculture In Tourism Rural, In Applied Studies In Agribusıness and Commerce (Abstract), Vol. 4, No.1-2, (2010) 59-64.
[6] H. Marques. Searching for complementarities between agriculture and tourism – the demarcated wine-producing regions of northern Portugal. Tourism Economics, (2006) 12, (2006) 147–155.
[7] A. Gannon. Rural Tourism As A Factor İn Rural Community Economic Development For Economies İn Transition. Journal of Sustainable Tourism, Vol. 2(1 + 2), (1994) 51–60.
[8] Socio-Economic Situation of the RA in January-December 2018, NSS of the RA (in Armenian).
[9] Travel & Tourism Economic Impact 2018 Armenia, World Travel and Tourism Council, 2018.
[10] Balance of Payments of the Republic of Armenia for 2010-2017, https://www.cba.am/am/SitePages/statexternalsector.aspx (accessed 13.03.18).
[11] Marzes and Yerevan city of the Republic of Armenia in figures, 2018.
[12] Tourism, Ministry of Economy of the RA, http://mineconomy.am/arm/39/gortsaruyt.html (accessed 13.03.18).
[13] The local self-government system, Ministry of Territorial Administration and Development of the RA, http://www.mtad.am/hy/the-lsg/ (accessed 13.03.18).
[14] Number of De Jure Population of the Republic of Armenia as of October 1, 2017 (in Armenian), http://armstat.am/en/?nid=82&id=1973 (accessed 13.03.18).
[15] Agrarian policy, Ministry of Agriculture of the RA, http://minagro.am/ (accessed 13.03.18).
[16] Statistical Yearbook of Armenia 2017, p. 299, http://armstat.am/file/doc/99504398.pdf (accessed 13.03.18).
[17] Fred R. David, Strategic Management: Concepts (13th ed.). Prentice Hall, New Jersey, 2011, http://irresearchers.ir/upload/docs/StrategicManagementDavid.pdf (accessed 13.03.18).

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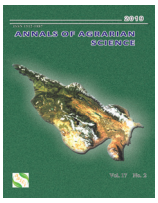

Oribatid mite communities on former clay quarries under different reclamation strategy

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A B S T R A C T

In order to establish or regenerate ecosystems in severely disturbed mining sites, reclamation activities are common practice. However, the effectiveness of reclamation strategy might be depended on the specific conditions of the area under question. To evaluate the effect of provided reclamation activities, we investigated structure and composition of oribatid mite communities at an early succession stage in the abandoned Kaspi clay pit. Effectiveness of natural succession and two alternative reclamation activities was evaluated: 1. M1 - do-nothing approach on land under natural secondary succession; 2. M2 - smoothed ground surface with sown seed mixture of herbs and pasture grasses; 3. M3 -three fenced plots with sown grasses and tree seedlings. Neighboring overgrazed natural meadow is chosen as control. Results show that the "do-nothing" approach with leaving post-mining sites without any reclamation is the worse strategy in development of soil oribatid community on lands without "source" area for vegetation (and consequently for soil humus layer) development. Reclaimed fenced areas were relatively poor by oribatid species richness compared to surrounding reclaimed (but not fenced) or natural areas. High abundance of stress tolerant species in fenced sites shows that the time interval between fencing (2012, 2013 and 2014) and sampling (2015-2016) was not enough for soil structure and faunal recovery and longer period is needed to establish sustainable oribatid communities.

Keywords: Oribatid mites, Colonization, Reclamation, Mining, Secondary succession, Overgrazing.

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1. Introduction

Natural regeneration of destroyed soil ecosystems (e.g. abandoned open mining areas) could take a long time [1-3]. Reclamation activities are frequently used to enhance ecosystem regeneration processes and help establishment of the biota in disturbed areas. However development of viable soil communities may still need several decades depending on the structure of reclaimed soil [4-6], distance from colonization sources [7-10], age of restored sites [11, 12] etc. Neighboring areas usually serve as a main source for colonization of soil arthropods , however the rate and mode of colonization is supposedly taxon specific. For instance, active dispersal ability of or batid mites (one of the most abundant and ecologically important groups) in the soil is limited to several centimeters [13] while ground beetles are fast, long distance runners . It has also been shown that the dispersal rate in slow-moving taxa (such as soil mites) can be assisted by passive pathways so that the species could frequently persist in remote non-viable habitat patches [14] and may play an important (if not concomitant) role in the structuring of mites communities at early stage of succession [13, 15-17]. Accordingly, deep knowledge of the processes that support the development of soil arthropod communities can help establishment in successful reclamation strategies.

Different activities can be employed during the reclamation process including but not limited to reshaping site surface, planting trees or sawing grasses, applying fertilizers and adding organic products and so on [18]. Depending on the target ecosystem component, different reclamation activities can be used. For instance, regeneration soil and its biota

(as example in an open mining areas with heavily degraded soil surfaces) one has to provide soil substrate and allow recolonization of soil dwelling animals. In addition, other aids can also be applied to support soil process (e.g. sowing grasses). Accordingly, adopting particular reclamation strategy can have a significant role on regeneration efficiency.

Unfortunately there are still insufficient investigations studding soil recovery process in open mining sites and in particular recovery of arthropod communities [19] ensuring no effective reclamation management. Furthermore, any particular reclamation activities undertaken until now in Georgia are only based on expert opinions rather than scientifically informed [20] usually followed no post reclamation monitoring and evaluations.

In this work we investigated the effect of provided reclamation activities on the structure and composition of oribatid mite communities at an early succession stage in the abandoned Kaspi clay pit. Oribatid mites are one of the most diverse and abundant group in soil matrix [21] and play an essential role in soil food web [22]. In addition, diversity of oribatid mites are the most intensively studied in Georgia [23] making this group useful for ecosystem evaluation [24]. Thus, unraveling the effects of reclamation activities on the development of oribatid mite community can help to better understand the succession of soil process. In 2012 Heidelberg Cement Caucasus Company began reclamation of the former clay pitarea applying different management strategy including different combinations of surfaceres haping , herb sowing, providing organic source and fencing [20]. Our aim was to evaluate the response of oribatid communities towards provided reclamation activities and to identify the best management strategies. We hypothesized that the fenced and smoothened surface with sowed grass and added organic content supports fastest recolonization and highest diversity of oribatid mites due to higher food supply and less physical disturbance; Though natural succession can lead to formation of diverse oribatid community [10], we were keen to understand how much the community succession rate depends on regeneration time provided in absence of physical disturbance (such as trampling).

2. Material and Methods

2.1. Study area

Kaspi clay pit represents a south western suburb of the Kaspi city (Georgia) (41.93; 44.39). The climate of the area is sub-Mediterranean with average annual temperature 13°C and annual precipitation 490 mm. The area of the former pit represents a flat depression on the left bank of the river Kura (Fig. 1) with license area of approximately 100 ha and open Kaspi clay pit area - 28.32 ha [20]. After 50th of the last century irregular mining activities were initiated that continued until 2006, after that time Heidelberg Cement Caucasus Ltd resurrected active mining that lasted until 2010. The quarry is surrounded by farmland area,is covered by ruderal vegetation and is extensively used for livestock grazing. For reclamation purposes three type of management have been applied: approach 1. Do-nothing – about 10 ha of area was left untouched with natural secondary succession (M1 – first management category); approach 2 – reclamation activities included smoothened ground surface and sowing commercial seed mixture with herbs and pasture grasses (M2 – second management category); approach 3 – three plots in reclaimed area were fenced each in 2012, 2013 and 2014 to restrict cattle movement. In each plot hay was added immediately as a supply of organic source (M3 – third management category) and seedlings of different species (mostly *Elaeagnus angustifolia* (Russian olive) and *Celtis caucasica* (Caucasian hackberry)) were planted (Table 1; Fig. 1).

Unreclaimed area (M1) is represented with small irregular hills left after mechanical relocation of ground during the mining process (Fig. 1, Table 1). All the areas but M3 were subject of continuous overgrazing.

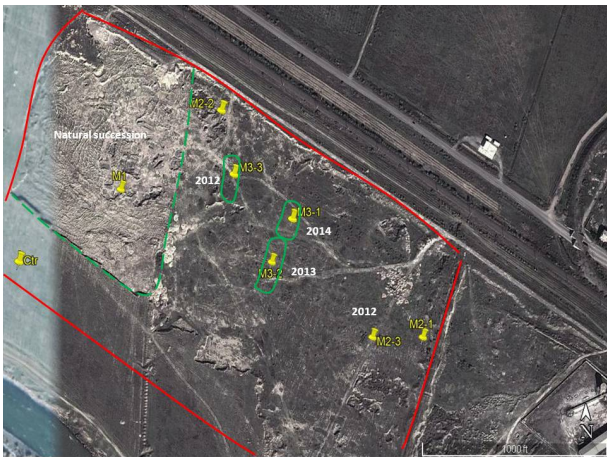


Fig. 1. *Kaspi clay pit with identification of sampling sites. Red solid line indicates area of reclaimed pit (M2), green solid lines show fenced plots (M3) and green dashed line shows area with natural succession (M1).*

Table 1. *Description of investigation sites with indication of observed and estimated (Chao) species richness. In the rightmost columns, site community data from the same management categories were pooled to evaluate overall management richness.*

Management Category	Sampling units	Site description	Coordinates	Site specific species richness		Management specific species richness	
				Species Richness	Estimated Richness	Species richness	Estimated richness
Ctr	Control	Natural overgrazed meadow. Plant coverage ~ 30%	N41°928 E44°391	23	30	23	29
M1	Not reclaimed	Natural succession on not reclaimed quarry. Overgrazed hills. Plant coverage < 20%	N41°929 E44°393	8	8	8	9
M2-1	Reclaimed	Natural seedlings of *Tamarix*	N41°927 E44°399	17	17	29	32
M2-2	Reclaimed	Grass sowed in 2012; Overgrazed; Plant coverage ~ 30%	N41°930 E44°527	23	24		
M2-3	Reclaimed	Grass sowed in 2012; Overgrazed; Plant coverage ~ 30%	N41°927 E44°398	17	19		
M3-1	Reclaimed fenced	Fenced in 2014; No grazing; Plant coverage ~ 50%	N41°929 E44°397	11	22	22	24
M3-2	Reclaimed fenced	Fenced in 2013; No grazing; Plant coverage ~ 80%	N41°928 E44°396	10	10		
M3-3	Reclaimed fenced	Fenced in 2012. No grazing; Plant coverage > 90%	N41°930 E44°340	15	15		

2.2. Sampling

In each management category (M1, M2, M3) and the surrounded control area (that was unaffected at least by mechanical disturbance), four 10 m^3 soil samples were taken randomly using soil corer in October 2015, February, May and July of 2016 (covering all four seasons). Soil samples were delivered in the laboratory and invertebrates were extracted using modified Berlese-Tullgren apparatus. Oribatid mites were collected in every 24 hours during one week. Extracted individuals were stored in 70% ethanol; temporary slides were made with lactic acid using hollow ground slides. Only adults were identified to species level using mainly keys of Weigmann [25] and Ghilarov and Krivolutsky [26]. Classification follows Schatz et al [27].

2.3. Data analysis

To compare species diversity and total abundance between different management units, we calculated total species richness for each management category as well as average species richness and individual density (per square meter) for each sampling unit. Later on, mean values were compared between management units using randomized block ANOVA where sampling period was used as a blocking factor and the management as a treatment. In addition to raw data, nonparametric estimators (Chao indices) and Simpson's diversity (1 - D) measures were used to consider sampling incompleteness in data analyses [28]. Cluster of faunal similarities we constructed using PAST software and based on Jaccard's similarity index.

3. Results

In total 3055 oribatid individuals belonging to 43 species from 25 families were identified (Table 2). Highest total number of species (29) was found in reclaimed overgrazed areas (M2-1 – M2-3) while lowest number (8 species) in not-reclaimed site (M1). Accordingly, this site showed lowest index of diversity (1-D = 0.15) (Table 1 and 3). Non-parametric estimators (Chao 1) showed the same trend and indicated a near complete inventory of species in almost all cases except Ctr where significantly

more species are expected than sampled (Table 1). 82% of individuals were represented by 7 dominant species only (*Punctoribates punctum* (C.L. Koch, 1839), *Oribatula (Z.) cognata* (Oudemans, 1902), *Pilogalumna crassiclava* (Berlese, 1914), *Tectocepheus velatus* (Michael, 1880), *Epilohmannia cylindrica* (Berlese, 1904), *Acrotritia ardua* (C.L. Koch, 1841), *Ramusella clavipectinata* (Michael, 1885)) among which *P. punctum* composed 56% of total individuals and dominated in all samples. Rare species *Scutovertex armazi* Murvanidze & Weigmann, 2012, was found on natural meadow. Up to date this species was known from type locality only (Armazi Mountain) [29].

Table 2. *List of Oribatid mites found on Kaspi clay pit with number of individuals for each site*

Species	M1	M2-1	M2-2	M2-3	M3-1	M3-2	M3-3	CTR
Epilohmannia cylindrica (Berlese, 1904)	3	8	7	49	1	14	68	14
Acrotritia ardua (C.L. Koch, 1841)	13	7	18	16	0	9	24	12
Nothrus anauniensis (Canestrini & Fanzago 1876)	0	0	0	0	0	0	0	4
Trhypochthonius tectorum (Berlese, 1896)	0	2	0	0	0	0	4	0
Belba dubinini Bulanova (Zachvatkina, 1962)	0	1	17	6	0	7	3	1
Metabelba italica (Sellnick, 1931)	0	0	0	2	0	0	0	0
Berlesezetes cuspidatus (Mahunka, 1982)	0	0	0	0	2	0	0	0
Dorycranosus splendens (Coggi, 1898)	0	0	0	0	0	0	0	1
Liacarus brevilamellatus (Mihelcic, 1955)	0	0	0	0	0	0	8	0
Xenillus tegeocranus (Hermann, 1804)	0	0	0	0	1	0	0	2
Ceratoppia quadridentata (Haller, 1882)	0	0	0	1	0	0	0	0
Carabodes sp.	0	0	0	0	0	0	0	1
Epimerella smirnovi (Kulijev, 1962)	0	0	0	1	0	0	0	0
Oppiella nova (Oudemans, 1902)	0	0	0	0	0	0	0	2
O. fallax (Paoli, 1908)	0	0	0	3	0	0	0	0
O. subpectinata (Oudemans, 1900)	0	0	0	2	0	0	0	0
Ramusella clavipectinata (Michael 1885)	1	65	7	50	1	2	13	5
Quadroppia quadricarinata (Michael 1885)	0	0	0	1	0	0	0	0
Suctobelbella subtrigona (Oudemans, 1916)	0	0	1	0	0	0	0	0
Tectocepheus velatus velatus (Michael, 1880)	0	13	28	10	0	5	12	2
T. velatus sarekensis (Trägårdh, 1910)	6	13	0	12	1	0	9	0
Tectoribates ornatus (Schuster, 1958)	0	0	1	0	0	0	0	1
Camisia horrida (Hermann 1804)	1	0	0	0	0	0	0	0
Scutovertex armazi (Murvanidze &Weigmann, 2012)	0	0	0	0	0	0	0	1
S. minutes (Koch, 1836)	0	2	2	6	0	0	8	4
S. sculptus (Michael, 1879)	0	4	3	5	1	1	0	7
Peloptulus phaenotus (C.L. Koch, 1844)	0	0	0	0	0	0	3	0
Parachipteria fanzagoi (Jacot, 1929)	0	0	0	2	0	0	0	0
Oribatella colchica (Krivolutsky, 1974)	0	0	0	0	0	0	0	1
Oribatula tibialis (Nicolet, 1855)	0	0	0	0	3	0	0	0
O. (Z.) cognata (Oudemans 1902)	2	1	43	97	12	0	12	70
O. (Z.) exavata (Berlese, 1916)	0	3	6	0	0	0	0	0
O. (Z.) frisiae (Oudemans, 1900)	2	38	0	0	0	0	0	0
O. (Z.) terricola (V.D. Hammen, 1952)	0	8	13	0	0	0	0	0
Simkinia tianschanica (Krivolutsky 1967)	0	0	1	2	0	0	10	32
Scheloribates leavigatus (C.L. Koch 1836)	0	0	0	1	0	0	0	0
Ceratozetes minutissimus (Willmann, 1951)	0	0	0	0	1	0	0	1
Punctoribates punctum (Koch, 1839)	335	152	141	247	29	94	450	276
Galumna flagellate (Willmann, 1925)	0	0	0	0	0	7	0	107
Pergalumna nervosa (Berlese, 1914)	0	14	5	2	0	2	5	3
Pilogalumna crassiclava (Berlese, 1914)	0	20	32	34	0	6	6	24
P. tenuiclava (Berlese, 1908)	0	0	0	2	0	0	0	0
Protoribates capucinus (Berlese, 1908)	0	12	15	24	1	0	0	1

Table 3. *Diversity indexes of oribatid mites on former Kaspi clay pit*

	CTR	M1	M2-1	M2-2	M2-3	M3-1	M3-2	M3-3
Taxa_S	23	8	17	23	17	11	10	15
Individuals	572	363	363	575	340	53	147	635
Dominance_D	0.289	0.853	0.228	0.235	0.214	0.358	0.430	0.517
Simpson_1-D	0.711	0.147	0.772	0.765	0.786	0.642	0.571	0.483
Evenness_e^H/S	0.245	0.185	0.421	0.309	0.452	0.398	0.393	0.230

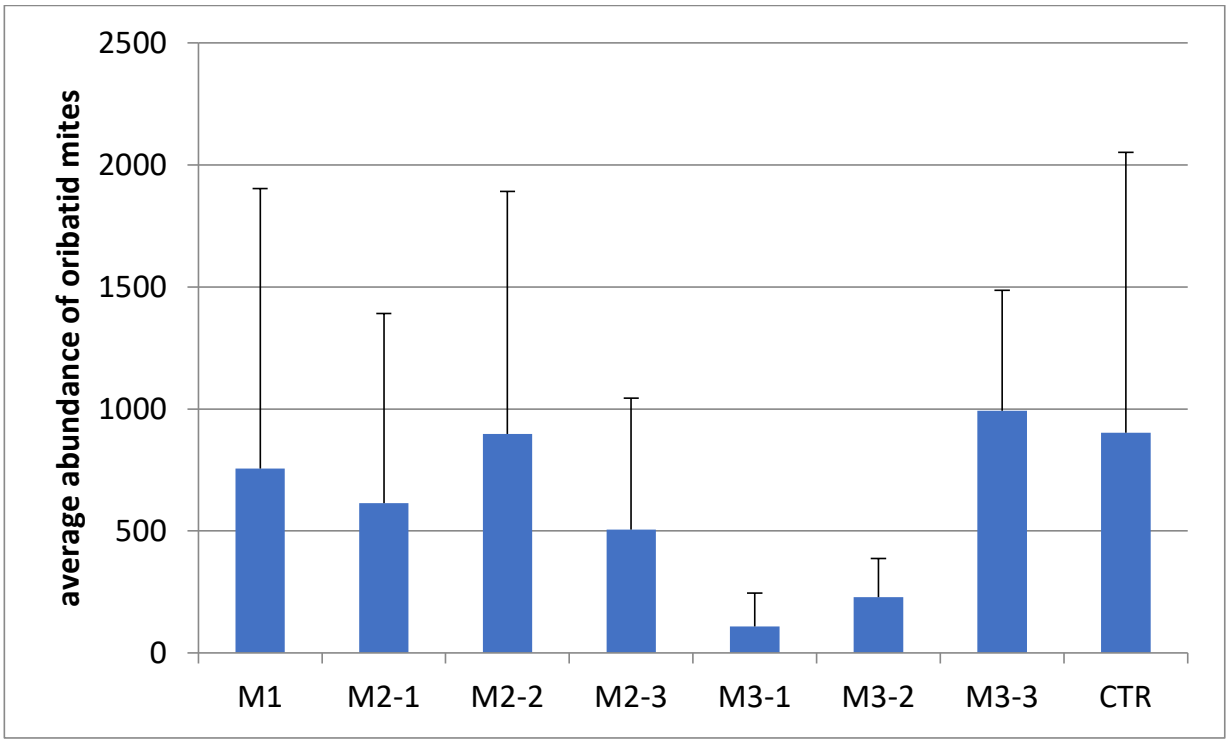
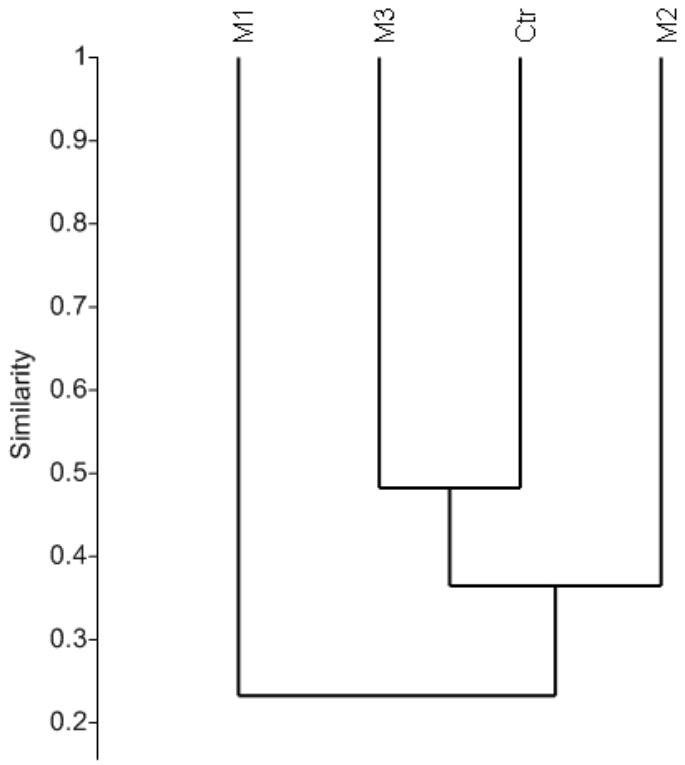


Fig. 2. *Average abundance of oribatid mites on investigated sites. Error bars indicates ±1 standard deviation.*

ANOVA model describing abundance and richness differences among management classes were significant (for main effects p ($F_{3,91}$) = 0.008 and p($F_{3,91}$) = 0.002 respectively). However, in case of abundance, only Ctr samples was significantly abundant (p = 0.027) compared to M3 samples, while there were no significant differences in other cases (Fig. 2). Similarly, sample species richness was significantly higher in Ctr cites compared to M3 (p = 0.006) and in M2 compared to M3 (p = 0.046).

Oribatid faunal composition showed higher similarity between Control and M3 sites while oribatids from unmanaged (M1) site were isolated from those with different management approaches (Fig. 3).

Fig. 3. *Cluster of faunal similarity between plots with different management activities (faunal similarity is based on Jaccard's coefficient).*



4. Discussion

Mining on Kaspi clay pit was stopped in 2009, while restoration activities were initiated in 2012 [20]. Our results show that the "do-nothing" approach with leaving post-mining sites without any reclamation is not effective strategy in development of soil oribatid community (and most probably whole soil ecosystem). This contradicts with our earlier finding which showed that natural succession can support even more diverse fauna than reclamation [10]. Effectiveness of natural succession is supported by other investigations as well [11, 25, 32]. Poor development of oribatid communities on M1 sites can be explained by two reasons: (1) time interval between stopping mining activities (2009) and sampling (2015) was not enough for development of oribatid fauna. More than 10 years are needed for faunal recovery [10, 19]; (2) there is no "source" area for vegetation (and consequently for soil humus layer) development around the whole area - M1 plots are surrounded by extensively overgrazed natural and reclaimed meadows without any forested territory. Intensive grazing leaves soil bare and exposed to wind erosion which makes it infertile and unsuitable for development of soil fauna. In our previous investigation neighboring forests served as a source for oribatid colonization on dump and abandoned quarry sites [10], hence we can conclude that presence of diverse habitat fragments speeds up secondary succession on former mining sites, while in their absence succession can be either very slow or impossible and active reclamation is strongly suggested.

In spite of high faunal similarity between control and fenced (M3) sites (Figure 2), opposite to our expectations, reclaimed fenced areas (that are protected from grazing) were relatively poor by oribatid species richness (plot species richness as well as total species diversity) compared to surrounding reclaimed (but not fenced) or natural areas. Fencing protects reclaimed sites from heavy overgrazing and leads to formation of dense vegetation cover with favorable conditions for soil fauna. However, as table 3 shows, evenness of species distribution in fenced sites tends to be lower compared to reclaimed unfenced areas and high abundance was provided by dominance of single species – *P. punctum.* This is true for M1 site as well, where high overall abundance is provided by *P. punctum*, when

the rest seven species are presented by minor quantities (Table 2). This species (with another co-dominant species like*T. velatus*) is known as cosmopolite one and an effective colonizer of disturbed habitats in early stages of soil recovery [9, 10, 32]. High abundance of these stress tolerant species in protected sites shows that the time interval between fencing (2012, 2013 and 2014) and sampling (2015-2016) was not enough for soil structure and faunal recovery. Moreover, for sensitive species that are heavily dependent on habitat quality and passive dispersal opportunities, fencing may pose an additional barrier for animals (e.g. cattle) who could contribute to passive dispersal of oribatids. Indeed, occurrence of species such as *Ceratoppia quadridentata* (Haller, 1882)*, Quadroppia quadricarinata* (Michael, 1885)*, Epimerella smirnovi* (Kulijev, 1962)*, S. armazi, Oribatella colchica* Krivolutsky, 1974*, Galumna flagellata* Willmann, 1925 in surrounding reclaimed areas which are not fenced, indicates that these species were not able to reach the fenced habitats. Previous investigations show that soil arthropods (and oribatid mites among them) can be passively dispersed by other vectors such as wind [13], birds [16], beetles [32, 34] and even frogs [35]. Nonetheless, it seems that none of above mentioned vector can be only responsible for mite colonization in Kaspi quarry areas. We suppose that the active livestock grazing in postmining sites while hindering effective development of vegetation cover and accumulation of organic material in soil [36], can support active translocation of soil arthropods from surrounding areas. Unfortunately, relatively little is known on the role of livestock in oribatid mite dispersal and our conclusions needs to be further corroborated.

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References

[1] P. Andrés, E. Mateos, Soil mesofaunal responses to post-mining restoration treatments, Appl. S. Ecol. 33 (2006) 67-78.

[2] H.B. Redi, R.J. van Aarde, T.D. Wassenaar, 2011. Coastal Dune Forest Development and the Regeneration of Millipede Communities, Restor. Ecol, 13 (2) (2011) 284–291.

[3] K. Prach, K. Rehounkova, J. Rehounek, P. Konvalikova, Ecological Restoration of Central European Mining Sites: A Summary of a Multi-site Analysis, Landsc. Res, 36 (2) (2011) 263–268.

[4] A.S. Zaitsev, N.M. van Straalen, Species diversity and metal accumulation inoribatid mites (Acari, Oribatida) of forests affected by a metallurgical plant. Pedobiologia 45 (2001) 467–479.

[5] P.Skubała , M.Ciosk , Oribatid mites (Acari, Oribatida) colonizing the zinc metallurgic dump, Fragm. Faun. 42 (6) (1999), 41-55.

[6] P. Skubała, K. Rola, P. Osyczka, Oribatid communities and heavy metal bioaccumulation in selected species associated with lichensin a heavily contaminated habitat. Environ. Sci. Pollut. Res. 23 (2016) 8861–8871. DOI 10.1007/s11356-016-6100-z.

[7] P. Skubała, Colonization of a dolomitic dump by oribatid mites (Acari, Oribatida), Pedobiologia 43 (1999) 145-159.

[8] P.Skubała, A.Kafel , Oribatid mite communities and metal bioaccumulation in oribatid species (Acari, Oribatida) along the heavy metal gradient in forest ecosystems, Environ. Pollut. 132 (2004) 51-60.

[9] P.Skubała, M.Gulvik , Pioneer oribatid mite communities (Acari, Oribatida) in newly exposed natural (glacier foreland) and anthropogenic (post-industrial dump) habitats, Pol. J. Ecol. 53 (3) (2005) 395–407.

[10] M. Murvanidze, L.Mumladze , T. Arabuli, Er. Kvavadze,Oribatid mite colonization on sand and manganese tailing sites, Acarologia 53 (2) (2013) 127-139.

[11] W. Dunger, M. Wanner, H. Hauser, K. Hohberg, H.J. Schulz, T. Schwalbe, B. Seifert, J. Vogel, K. Voigtländer, B. Zimdars, K.P. Zulka, Development of soil fauna at mine sites during 46 years after afforestation. Pedobiologia 45 (2001) 243-271.

[12] B.N. McAdams, S.A. Quideau, M.J.B. Swallow, L.M. Lumleyc, Oribatid mite recovery along a chronosequence of afforested boreal sites following oil sands mining, Forest Ecol. Manag, 422 (2018) 281–293.

[13] R. Lehmitz, D. Russell, K. Hohberg, A. Christian, W.E.R. Xylander, Active dispersal of oribatid mites into young soils, Appl. Soil Ecol. 55 (2012) 10–19.

[14] M. Ingimarsdóttir, T. Caruso, J. Ripa, Ó. B.

Magnúsdóttir, M. Migliorini, K. Hedlund, Primary assembly of soil communities: disentangling the effect of dispersal and local environment, Oecologia, 170 (2012) 745-754. DOI 10.1007/s00442-012-2334-8

[15] Sh. Karasawa, K. Gotoh, T. Sasaki, N. Hijii, Wind-based dispersal of oribatid mites (Acari: Oribatida) in a subtropical forest in Japan, J. Acarol. Soc. Jpn, 14 (2) (2005) 117-122.

[16] N.V. Lebedeva, Oribatid mites transported by birds to polar islands, a review, In: G. Hempel, K. Lochte, G. Matishov (Eds). Arctic Marine Biology. Reports on polar and marine research, Bremerhaven, Alfred Wegener Institute for Polar and Marine Research, 640, 152-161, 2012.

[17] R. Lehmitz, D. Russell, K. Hohberg, A. Christian, W.E.R. Xylander, Wind dispersal of oribatid mites as a mode of migration, Pedobiologia 54 (2011) 201–207.

[18] R. Tropek, T. Kadlec, M. Hejda, P. Kocarec, J. Skuhrovec, I. Malenovsky, S. Vodka, L. Spitzer, P. Banar, M. Konvicka, Technical reclamations are wasting the conservation potential of post-mining sites. A case study of black coal spoil dumps. Ecol. Eng. 43 (2012) 13-18.

[19] P. Skubała, Do we really need land reclamation on dumps? (Oribatid fauna case studies), In: G. Gabrys, S. Ignatovicz, (Eds), Advances in Polish Acarology, Wydawnictwo SGGW, Warszawa, 366-374, 2006.

[20] U. Tranke, Restoration concept Kaspi clay pit HeidelbergCement Caucasus ltd, Blaubeuren, 2012.

[21] M. Maraun, H. Schatz, S. Sheu, Awesome or ordinary? Global diversity patterns of oribatid mites, Ecography (2007) 209-2016.

[22] K. Schneider, C. Renker, S. Scheu, M. Maraun, Feeding biology of oribatid mites: a minireview, Phytophaga (2004), 247 -256.

[23] M. Murvanidze, L. Mumladze, Annotated checklist of Georgian oribatid mites. Zootaxa 4089 (1) (2016) 1-81.

[24] V. Gergocs, L. Hufnagel, Application of oribatid mites as indicators (Review), Appl. Ecol. Env. Res. 7 (1) (2009) 79-98.

[25] G. Weigmann, Hornmilben (Oribatida), Die Tierwelt Deutschlands, Teil 76, Goecke & Evers. Keltern, 2006.

[26] M.S. Ghilarov, D.A. Krivolutsky, Identification keys of soil inhabiting mites, Nauka, Moscow, 1975. (in Russian)

[27] H. Schatz, V.M. Behan-Pelletier, B.M.O Connor , R.A. Norton, Suborder Oribatida van der Hammen, 1968. *In*: Zhang, Z.Q. (Ed), Animal biodiversity: An outline of higher level classification and survey of taxonomic richness. Zootaxa 3148 (2011) 141-148.

[28] A. Magurran, Measuring Biological Diversity, Blackwell Publishing, Oxford, RU, 2004.

[29] M. Murvanidze, G. Weigmann, Two new species of oribatid mites (Acari, Oribatida) *Haplozetes longisacculus* and *Scutovertex armazi* from Georgia (Caucasus), Acarina 20 (2) (2012) 167-172.

[30] P. Skubała, Moss mites (Aearina : Oribatida) on industrial dumps of different ages, Pedobiologia 39 (1995)170-184.

[31] M. Murvanidze, N. Todria, Oribatida diversity on limestone and clay quarries. Proc. Inst. Zool, 24 (2015) 159-169.

[32] W. Dunger, M Wanner, H. Hauser, K. Hohberg, H.J. Schulz, T. Schwalbe, B. Seifert, J. Vogel, K. Voigtländer, B. Zimdars, K.P. Zulka, Development of soil fauna at mine sites during 46 years after afforestation. Pedobiologia 45 (2001) 243-271.

[33] S. Ermilov, A. Frolov, *Ramusella* (*Dosangoppia*) *bochkovi*(Acari, Oribatida, Oppiidae), a new subgenus and species of oribatid mites phoretic on *Ceratophyus polyceros* (Pallas, 1771) (Coleoptera, Geotrupidae) from Russia, Syst. Appl. Acar. 24 (2) (2018) 209–221.

[34] E. Waleckx, T. J. Montalvo-Balam, A. Pinzón-Canua, A. Arnal, G. Marti, P.A. Martínec, First report of phoresy by an oribatid mite (Acari: Oribatida) on a triatomine bug(Hemiptera: Reduviida), Int. J. Acar. 44 (4-5) (2018) 210-211. DOI:10.1080/01647954.2018.1487467.

[35] L.E. Beaty, H.J. Esser, R.M. R.A. Norton, First report of phoresy by an oribatid mite (Trhypochthoniidae: *Archegozetes magnus*) on a frog (Leptodactylidae: *Engystomopspus tulosus*). Int. J.Acar, 39 (2013), 325-326.

[36] P.C.F. Carvalho, I.A.A. de Moraes, E.D. de Souza, R.M. Sulc, C.R. Lang, J.P.C. Flores, M.L. Terra Lopes, J.L.S. da Silva, O. Conte, C. de Lima Wesp, R.L.R.S. Fontaneli, C. Bayer, Managing grazing animals to achieve nutrient cycling and soil improvement in no-till integrated systems. Nutr.Cycl. Agroecosyst, 88 (2010) 259–273. DOI 10.1007/s10705-010-9360-x.

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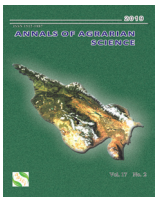
Journal homepage: http://journals.org.ge/index.php



First notes about parasitization of Cydia spp. (Lepidoptera: Tortricidae) damaging Oaks (Quercus spp.) and Oriental Beech (Fagus orientalis) in the Northern Caucasus

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A B S T R A C T

Species of *Mastrus* Förster (Ichneumonidae) attacking fruit-feeding Cydia species (Tortricidae) in gardens and stands of nut-bearing trees in the foothills and mountains of the Northern Caucasus are reported, including (1) *M. ridens*, (2) *M. gradibundus*, (3) *M. rufalus*, (4) *M. rufobasalus*, and (5) *M. sordipes,* from Cydia species: *Cydia amplana, C. fagiglandana* and *C. splendana*. The effectiveness of these *Mastrus* species as biocontrol agents of these *Cydia* species was studied on four oak species and on oriental beech.

Keywords: Parasitic wasps, moth, acorn, beech fruit, pests, species.

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Introduction

The species belonging to genus *Mastrus* (Hymenoptera, Ichneumonidae) are facultative parasitoids (mainly secondary, rarely primary, either solitary or gregarious) idiobiont ectoparasitoids of many lepidopterans. From a practical point of view, they are interesting as potential biocontrol agents of various species of moths. The successful introduction and establishment of *Mastrus ridens* Horstmann in the USA, Argentina, Chile, Australia and New Zealand [1] (Yazlovetsky and Djurich 2016) is an outstanding example of the biocontrol of the apple-feeding species, *C. pomonella*. The laboratory colony of *M. ridens* used in these programs was initiated with parasitoids from caterpillars collected by the trap-belts in the nut forests of the Tien Shan (Kazakhstan).

Species of *Mastrus* are known as the effective parasitoids of the apple-feeding moth *Cydia pomonella*, as well as the plum moth (*Grapholitha funebrana*), the grapevine moth (*Lobesia botrana*), and the vine moth (*Eupoecilia ambiguella*) [2].

Other, less well known species in *Cydia,* include *Cydia amplana* Hübner (hazelnut or red oak moth), *Cydia fagiglandana* Zeller (beech moth), *Cydia splendana* Hübner (acorn or gray oak moth) develop in oak acorns, beech fruits, hazelnut, chestnut seed, walnuts, apricots, apples, pears, plums, cherry plums, and quince [3] (Pribylova 1991).

In Georgia, stable forests occur that are composed of common oak (*Quercus robur*), sessile oak (*Q. petraea*), downy oak (*Q. pubescens*), strandzha oak (*Q. hatrwissiana*) and oriental beech (*Fagus orientalis*). The main *Cydia* pests of oak acorns and oriental beech fruits are *C. amplana*, *C. fagiglandana,* and *C. splendana*.

Our goal was to determine the distribution and trophic connections of species of the genus *Mastrus*, distributed in Northern Caucasus.

Material and Methods

Mastrus wasps were collected as a part of the program to study the biodiversity of beneficial or-

ganisms and the prospects for their application in biological plant protection, from May to October 2016-2017 in the foothills of North Caucasus, at four stationary points selected according to elevation from 250 to 1000 m above sea level, in apple and pear orchards, in areas surrounded by natural forest ecosystems. Parasitoids were collected in areas where chemical plant protection agents were not used.

To collect parasitoids for rearing, we used the cardboard boxes to rear hosts or parasitoids from fruits. Number of boxes deployed in the study varied from about 500 on the Maikop experiment station of the Federal Research Center the N. I. Vavilov All-Russian Institute of Plant Genetic Resources (Maikop ES of the VIR) to about 150 in St. Michael-Athos monastery, 70 in the village of Chibiy and 50 in the tract Planchenskaya Shchel'. The trapping bands were placed on the trunks of beech, oak, apple-tree, pear, cherry-plum and plum trees.

Cardboard boxes were 20-30 cm tall and the bottom of the box was covered with 3-5 cm of moistened forest soil. Fruits of beech and acorns, damaged by moths, were placed in boxes 7-15 cm in layer. Pupation of *Cydia* caterpillars took place in a layer of moistened forest soil on the bottom or on the boxes' walls. The material collected in this way was used to obtain *Mastrus* adultsto initiate parasitoid rearing colonies. In total, a little more than two thousand beech fruits and around three thousand acorns damaged by *C. amplana, C. fagiglandana* and *C. splendana* were collected and used to rear parasitoids.

Parasitoids were determined to species using the collections of the Zoological Institute of the Russian Academy of Sciences (St. Petersburg), the collection of the All-Russian Institute of Biological Plant Protection (Krasnodar), identification keys published by the Zoological Institute of RAS [2](Kasparian 1981) and keys to the parasitoids of pests, published by the All-Russian Research Institute of Biological Plant Protection[4,5] (Kostjukov et al. 2007; Kostjukov 2010).

Results

From acorns of oak (common, sessile, downy, strandzha) and in oriental beech fruits, we reared three *Cydia* species: *C. amplana, C. fagiglandana* and *C. splendana*, from which five species of *Mastrus* were reared: *M. ridens* Horstmann, *M. gradibundus* Gravenhorst, *M. rufalus* Thomson, *M. rufobasalus* Habermehl, and *M. sordipes* Gravenhorst. These *Mastrus* species are native in the Northern Caucasus region of Georgia, living in foothills, mountainorchards, and walnut forests.

Beech

On beech, the parasitization rate of *C. amplana* by Mastrus species was 9.3-12.7%, while the hosts *C. fagiglandana* and *C. splendana* were attacked at 8.7-11.3% and 12.3-14.7%, respectively. The lowest rate of parasitism occurred at the end of June, and the highest, at the end of October.

Parasitism rates of *C. fagiglandana* were slightly lower that those of *C. amplana* and *C. splendana*, and parasitization rate of *C. splendana* was higher compared to *C. amplana*. Significant differences in the parasitism rates of *C. amplana, C. fagiglandana* and *C. splendana* by *Mastrus* species at different study sites were found. At the St. Michael-Athos monastery, the level of infestation by Cydia species was about 15%; In the village of Chibiy and Maikop Experiment Station of the Federal Research Center the N. I. Vavilov All-Russian Institute of Plant Genetic Resources (ES of the VIR), was slightly more than 8.5%.

Damage to the fruits of the oriental beech (*Fagus orientalis*) by *C. amplana, C. fagiglandana,* and *C. splendana* was: in Maikop ES of the VIR, 7.8%; in the village of Chibiy, 8.5%; in the tract called Planchenskaya Shchel', and 12.3%; in the St. Michael-Athos monastery 18.7%.

Oak

On oaks, the picture was different: parasitism of *C. amplana* by *Mastrus* species during the vegetative period was 21.7-26.3%, and the maximum parasitization rates were recorded at the end of the period of emergence of adult parasitoids at the end of October. The parasitization rate of *C. fagiglandana* parasitoids of the genus *Mastrus* ranged from 24.7% at the end of June to 30.3% at the end of October. Pupae of *C. splendana* were parasitized with parasitoids of the genus *Mastrus* by 23.7% at the end of June and by 29.3% at the end of October.

Thus, parasitization of *C. amplana* by *Mastrus* species throughout the entire observation period was slightly lower than parasitism of *C. fagiglandana* or *C. splendana*. There were no significant differences in parasitism of *Cydia* species on *Quercus* species, at different points of observation. At the St. Michael-Athos monastery, parasitism was 24.7-30.3%, while in the tract Planchenskaya Shchel' it was 26.3-30.3%. In the village of Chibiy, parasitism was 23.7-29.3% and at the Maikop ES site of the

VIR, parasitism was 21.7 to 29.3%. It can only be noted that the lowest rate of parasitism in the tract Planchenskaya Shchel' was slightly higher (26.3%) than at other sites, and in the VIR Experimental Station, the minimal rate was slightly lower (21.7%) than at other sites.

Damage levels to acorns by *C. amplana, C. fagiglandana,* and *C. splendana* were as follows: on the Maikop ES of the VIR, 12.3-18.7%; in the village of Chibiy, it was 19.7-24.3%; in the tract Planchenskaya Shchel', 26.7-30.3%; and in the St. Michael-Athos monastery, parasitism was 31.3-52.7%.

Conclusion

This study of species of *Mastrus* Förster (Ichneumonidae) in the foothills, mountain gardens and the nut-bearing forests of the North Caucasus, found parasitism by five parasitoid species in this(*M. ridens*, *M. gradibundus*, *M. rufalus*, *M. rufobasalus*, *M. sordipes*) on caterpillars of *Cydia* moths (*C. amplana, C. fagiglandana* and *C. splendana*) developing in acorns and fruits of oriental beech: .

Parasitism of Cydia moths developing in the fruits of oriental beech, varied from 8.7 to 14.7%, the minimum level was recorded at the end of June, and the maximum at the end of October. The damage of the fruits of the beech by the moths *C. amplana, C. fagiglandana* and *C. splendana* ranged from 7.8 to 18.7%.

Parasitization of larvae of *Cydia* moths developing acorns of various oaks varied from 21.7 to 30.3%; The lowest level of parasitism was recorded at the end of June, and the highest level at the end of October. The damage of acorns by *C. amplana, C. fagiglandana,* or *C. splendana* varied from 12.3-18.7% in the Maikop ES of the VIR to 31.3-52.7% in the St. Michael-Athos Monastery.

The fruits of Oriental beech and acorns of several oaks that are infested by *C. amplana, C. fagiglandana,* or *C. splendana* are an important reserve of Mastrus species (*M. ridens, M. gradibundus, M. rufalus, M. rufobasalus* and *M. sordipes*).

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Conflicts of interest: Authors declare that there is no conflict of interest.

References

[1] Yazlovetsky I.G. & Djurich, G.F., Feasibility of the introduction of their mammothide *Mastrus ridens* (Horstmann) in the gardens of the Republic of Moldova. Biologicheskaya Zashchita rasteniy - osnova stabilizatsii agroekosistem (Biological Plant Protection as the Basis of ecosystem stabilization), Krasnodar, 9, 2016, pp. 180–186.

[2] Kasparyan D.R., Family Ichneumonidae. In Medvedev G.S., (Ed) Keys to the Insects of European Part of the USSR, Vol. 3, Part 3, Nauka, Leningrad, 1981 (in Russian).

[3] Pribylova M.V., Insects - pests of forest seeds of the North Caucasus / North-Caucasian Forest Experimental Station of the Caucasian Foundation VNIILM-Krasnodar, 1991 (in Russian).

[5] Kostjukov V.V., The Key to the Parasites of Harmful and Useful Arthropods of Corn Crops, Alev, Krasnodar, 2010 (in Russian).

[4] Kostjukov, V.V., Kosheleva O.V. & Balakhnina I.V., The Key to the Parasites of Pests of the Fruit Garden, Foundation, Rostov-on-Don, 2007 (in Russian).

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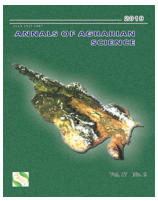

Preliminary Screening Some Potato Cultivars for Resistance to Potato Wart in Georgia

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A B S T R A C T

Potato wart (*Synchytrium endobioticum)* is a very important quarantine disease worldwide. The disease was first found in Georgia in 2009. Because of the unreliable chemical control to eliminate the pest in the soil, it is applicable to cultivate potato varieties resistant to the pathotypes present in the infested plots. To prevent the disease spread, it is very important to test imported potatoes for the resistance to the disease before commercially releasing them in fields. The preliminary assessment of introduced commercial potato cultivars for resistance to potato wart in infested plots was carried out using the field test in Skvana and Uchkho villages, and the pot test for Didajara village in Khulo municipality. As a result of screening, potato cultivars showed the different reactions to potato wart in field and pot tests. The majority of the tested cultivars were susceptible to the wart and only several cultivars showed resistance in separate tests.

Keywords: Potato varieties**,** Potato wart, Resistance, *Synchytrium endobioticum*, Screening, Pathogen.

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Introduction

The main parts of potato plantations are located in mountainous areas of Western and Southern Georgia. According to the data of GeoStat (2017), the average yield of potato is still low and ranges from 8 to 11 t/ha [1]. One of the important limiting factor in potato production in Georgia is potato wart caused by the obligate biotrophic, soil-borne fungal pathogen *Synchytrium endobioticum* (Schilb.) Perc. [2, 3].

The pathogen included on A2 quarantine list of EPPO occurs locally in almost all countries in the EPPO region [4, 5], including Georgia where it was first found in Didajara and Tabakhmela villages of Khulo municipality in 2009. In 2010-2012, the disease was found in other villages in Khulo on varieties Agria, Finka, Picasso and Marfona [6]. Later, disease foci were also found in various private plots in Mestia municipalities in the region of Samegrelo-Zemo Svaneti [7]

Potato wart (PW) is a very harmful disease [8]. The diseased tubers are unmarketable because of proliferating warts on potato tubers, formed during the growing season that may continue developing after harvest [9]. The resting spores of the causative agent survive in soils and can be infectious for 20-50 years [10]. Therefore, infested plots cannot be used for potato production for more than 20 years after the detection of the pest [11]. Yield losses may vary between 50-100 % under conditions favorable to disease development [12].

Furthermore, the fungus develops new pathotypes that are a serious threat to disease control because a new race can infect already existing resistant potato varieties to PW. Today, more than 40 pathotypes of the pathogen have been known [13-15]. Among them, the pathotypes 1(D1), 2(G1), 6(O1), 8(F1) and 18(T1) are the most important

in Europe [16]. As the results of the collaborative work between labs in Georgia and the Netherlands for the determination of pathotypes present in Georgia conducted in 2013-2017 years, the presence of pathotype 38 (Nevşehir) in Didajara village of Khulo municipality was reported [17], which is expected to spread in Georgia from Turkey while exporting potato crops.

Because of the elimination of the pest in the soil is impossible through chemical control, the only available strategy to prevent further spread of the disease is to apply strict phytosanitary measures combined with the cultivation of potato varieties resistant to the pathotypes present in the infested fields [18].

As potato producers in Georgia do not practice the local selection and seed production, potatoes are imported from Armenia, Turkey, Germany, Iran, the Netherland, and other countries. Some potato cultivars Marfona, Picasso, Agria, Finka, Impala introduced in Georgia in 90th years of the previous century are growing despite their susceptibility to the wart. To prevent the disease spread, it is very important to test imported potatoes for the resistance to PW before planting them in the field.

This paper presents the results of the preliminary assessment of introduced potato cultivars for resistance to potato wart. The purpose of this study is to reveal the resistant varieties to wart in Khulo conditions and by that to meet the requirements of technical regulation for potato wart control accepted by the Georgian government in 2015 to prevent its spread in Georgia [19].

Material and methods

The potato cultivars grown in Georgia and some new cultivars were assessed for the reaction to PW using pot and field tests.

Pot test. Pot trials were conducted in 2016. Samples of soil (with density of 22 winter sporangia per g soil) originated from infested fields located in village Didadjara, Khulo mountain region were placed in pots (5 L) and 37 introduced cultivars (Pekaro, Spunta, Jelly, Nandina, Panamera, Omega, Artemis, Figaro, Bernadette, Europrima, Marfona, Marabel, Estela, Alwara, Agria, Saturna, Sylvana, Glorietta, Impala, Laura, Arnova, Sofia, Annalena, Arizona, Fabula, Caruso, Finka, Arinda, Milva, Sante, Meskhuri tsiteli, Javakheturi, Meskhuri, Briz, Skrab, Uladar, Lileya were planted. Each pot contained 2-3 tubers and three replications per cultivars were used. Cultivar Marfona served as positive control. The pots were placed in a glasshouse at the end of autumn with supplementary lighting and handy washing to keep suitable soil moisture. The temperature and the relative humidity in glasshouse varied between approximately 18-20^0 C and 70-85%, respectively. When tubers formed, plants were removed from pots, and wart development was evaluated for the stem base, stolons and tubers. Wart symptoms were assessed by the Spieckermann scale [20].

Field test. In 2017-2018, field tests were conducted in Skvana and Uchkho villages of Khulo municipality. Before planting potato cultivars, the soil samples were collected from the infested foci and examined for the presence of the resting sporangia of *S. endobioticum* under a microscope. The density of sporangia per gram of soil was also determined (EPPO, 2004). As a result of a direct examination, 12 sporangia per g soil were revealed in the infested soil of Skvana village and 8 sporangia in the soil of Uchkho village.

Tubers were planted at a distance of 70 X 30 cm. 5-10 tubers per tested cultivar were planted by hand. The number of tubers planted in the fields was depended on the number of seed potatoes available. By the end of growing season, the tubers were harvested by hand and the wart development was evaluated. When a single wart with winter sporangia was formed, the cultivar was rated as susceptible. When no such reaction has occurred, the cultivar was rated as resistant. The disease severity in the fields was evaluated for each plant separately according to the number and the size of warts using the scale specified in the EPPO Diagnostic Protocol (EPPO, 2004).

In 2017, the field test in the infested private plot was conducted at an altitude of 1291 m above sea level (N41*32.875, E04*29.098) in Skvana village where average air temperature was ~ 8^{0}C, humidity 70-80%. The cultivars Marfona, Marabel, Briz, Lileya, Uladar, Agria, Impala, Laura, Saturna, Sylvana, Glorietta, Meskhuri, Javakheturi, Skrab, Estela, Alwara were planted on early May and harvested on early September.

In 2018, the field test in the infested private plot was carried out at an altitude of 1083 m above sea level (N41.40.969, E042.18513) in Uchkho village (average air temperature ~ 12^{0}C, humidity 85%). In Khulo the brown forest soils with low acidity have occurred. The cultivars Pekaro, Spunta, Red Fantasy, El mundo, Leandra, Andrea, Catania, Jelly, Florente, Carlita, Captiva, Cardinia, Coronada, Nandina, Pan-

amera, Magda, Artemis, Figaro, Bernadette, Europrima, Marfona, Marabel, Lileya, Agria, Saturna, Sylvana, Glorietta, Javakheturi, Meskhuri, Skrab, Briz, Uladar, Estela, Alwara were planted on early April and harvested in late July. After harvesting, each plant was evaluated separately according to the number and size of the warts using the scale (Table 1).

Results and discussion

Pot test. According to the results of the pot test (Table 1) from thirty-seven cultivars of potato tested for wart resistance the majority of the cultivars Nandina, Glorietta, Bernadette, Marfona, Pekaro, Panamera, Spunta, Annalena, Estela, Europrima, Sylvana, Finca, Laura, Figaro, Impala, Jelly, Alwara, Artemis, Milva, Agria, Sante Saturna, Briz, Lileya, Skrab, Uladar, Meskhuri tsiteli, Meskhuri and Javakheturi showed susceptible reaction. Among them, warts at the stem base were formed on cultivars: Nandina, Panamera, Annalena, Skrab, Europrima, Sylvana, Finca, Impala and Sante. The cultivars Arnova, Sofia, Arizona, Fabula, Caruso, which are reported to be resistant to pathotype D1 of wart were also resistant in pot test, but the German cultivar Omega and the Dutch cultivar Arinda reacted as resistant in our experiment are characterized as susceptible to pathotype D1 in accordance with the catalogues [21,22]. This could be explained by the fact that pathotype 38 was identified in Didajara district (unpublished data) [17].

Field test. Sixteen and thirty-four cultivars were evaluated in the infested fields in Skvana village in 2017 and in Uchkho village in 2018, respectively. Cultivars that were available in those years were planted in the fields. The most of the cultivars (Marfona, Impala, Laura, Glorietta, Meskhuri, Javakheturi, Skrab, Estela, Alwara, Briz, Lileya, Uladar, Saturna,) tested in Skvana field were susceptible to the wart and only three cultivars Agria, Sylvana and Marabel showed resistance (Table 2).

Table 1. *Reaction of potato cultivars to PW using pot test (Spieckermann scale) in 2016*

N	Cultivars	Number of tuber eyes recorded	Number of diseased tubers	Resistant				Susceptible							Symptoms on other parts of	Overall Reaction
				0	1	2	3	4	5							
				0	-	P	F	R	I	II	III	IV	V	X		
1	Marfona	24	14	10					4	2		4	3	1		S
2	Nandina	19	7	12						4	1	1	1		Wart at the stem bases – 4 cm	S
3	Glorietta	13	7	6					4		1		2			S
4	Bernadette	19	4	15					1		**2**	1	2			S
5	Arnova	11	0	11												R
6	Pekaro	39	14	10		15			7		2	3	2			S
7	Sofia	13		8		5										R
8	Agria	16	4	12												S
9	Spunta	22	7	9		6			3	2	1	1				S

10	Panamera	25	5	20						1	3	1			Warts at the stem bases – 2 - 3 cm	S
11	Artemis	12	4	8					2	1	1					S
12	Milva	11	7	4					2	1	1	1	1	1		S
13	Annalena	21	5	6		10				2	2	1			Warts at the stem bases – 1 cm;	S
14	Estela	18	5	13					1	2	2					S
15	Arizona	7	0	7												R
16	Marabel	15	4	15					2	1	1					S
17	Europrima	7	3	4						3					Warts at the stem bases – 2 cm;	S
18	Fabula	25	0	21		4										R
19	Caruso	13	0	0		13										R
20	Laura	7	2			5			1	1						S
21	Sylvana	12	2	8		2			2						Warts at the stem bases – 1.5 cm;	S
22	Omega	20	0			20										R
23	Finca	30	7			23			6	1					Warts at the stem bases – 3 cm;	S
24	Figaro	23	5	18					2	2	1					S
25	Arinda	11	0			11										R
26	Sante	22	6	16						1	2	2	1		Warts at the stem bases – 2,5 cm;	
27	Jelly	12	4	8					1	1	2					S
28	Impala	21	12	9					3	4	4		1		Warts at the stem bases 1.3– 2 cm;	S
29	Alwara	13	5			8			2	2	1					S
30	Saturna	20	6	12		2			2	1	2	1				S

31	Skrab	12	5	7					2	1	1	1			Warts at the stem bases – 4 cm;	S
32	Briz	18	8	4		6			2	2	3	1				S
33	Lileya	20	11	5		4			4	3	2	2				S
34	Uladar	17	6	11						2		3	1			S
35	Meskhuri Tsiteli	15	7	8						2	3	1	1			S
36	Meskhuri	18	6	10		2					3	2	1			S
37	Javakheturi	16	5	11						1	3	1				S

**0, no reaction visible; type –, or 1-early defence necrosis; type 2 or P- late defence necrosis; type 3 or F, very late defence necrosis; type 4 or R, weakly susceptible, type 5 or susceptible (wart types I, II, III, IV, V, and X): I (2–3 mm diam), II (4–5 mm), III (6–7 mm), IV (8–10 mm), V (11–15 mm) and X (16–20 mm and bigger). S, susceptible reaction; R, resistant reaction.*

However, wart proliferations were visible on the tubers of these cultivars in the field test conducted in Uchkho and pot test with inoculum from Didajara village.

Table 2. *The results of reaction types of potato cultivars to PW during the field test in the village of Skvana, 2017*

N	Potato cultivars	Total number of tubers	Diseased	Rotten	Scale									
					1 Class	2 Class	3 Class	4 Class	5 Class	6 Class	7 Class	8 Class	9 Class	Reaction Type
1	Marfona	24	7		17	2	3						2	3 (S)
2	Marabel	9			9									1 (R)
3	Briz	44	13		31	1	2		3	2	5			7 (S)
4	Lileya	76	23		53	7	3	5	5	1	1	1		2 (S)
5	Uladar	31	11		20		4	3	2	2				3 (S)
6	Agria	6			6									1 (R)
7	Impala	52	16		36	2	4	5	3	2				4 (S)
8	Laura	9	5		6		3	1	1					3 (S)
9	Saturna	71	19	1	52			3	4	6	1	2	1	6 (S)
10	Sylvana	69			69									1 (R)
11	Glorietta	23	9	16	14	2	3	1	2	1				3 (S)
12	Meskhuri	21	8	11	13	4	2	1	1					2 (S)
13	Skrab	26	9		17			5	2	1	1			4 (S)
14	Estela	32	11		21	2			4	2	2	1		5 (S)
15	Alwara	28	12		16		3	4	2	2	1			4 (S)
16	Javakheturi	20	8			3	2	2	1					2 (S)

Thirty- one cultivars (Europrima, Bernadette, Figaro, Magda, Panamera, Nandina, Coronada, Captiva, Carlita, Florente, Jelly, Andrea, El mundo, Red Fantasy, Pekaro, Estela, Marfona, Sylvana, Marabel, Agria, Artemis, Alwara, Spunta, Glorietta, Lileya, Saturna, Briz, Uladar, Scrab, Meskhuri and Javakheturi planted in the field trial of Uchkho showed the susceptible reaction to potato wart. The remaining three cultivars Catania, Lendra and Cardinia which are reported to be resistant to D1 [23] were also resistant in Uchkho field trial (Table 3).

Table 3. *The results of reaction types of potato cultivars to PW during the Field Test in the Village of Uchkho, 2018*

N	Potato cultivars	Total number of tubers harvested	Diseased	Rotten	Scale									
					1 Class	2 Class	3 Class	4 Class	5 Class	6 Class	7 Class	8 Class	9 Class	Reaction Type
1	Marfona	21	5		16	1			4					5 (S)
2	Sylvana	37	9	3	28	3	4	2						3 (S)
3	Marabel	13	7	1	5		7							3 (S)
4	Europrima	15	14		1	8		3			2	1		2 (S)
5	Bernadette	22	6	1	15	1	3				1		1	3 (S)
6	Figaro	40	10		30	3	4	1				1	1	3 (S)
7	Agria	15	4		11		2	1	1					3 (S)
8	Artemis	20	0		15	3	1							2 (S)
9	Spunta	5	3		2		2	1						3 (S)
10	Estela	44	14		30	7	1	3	3					2 (S)
11	Alwara	16	11		5	4	1	2	2			1	1	2 (S)
12	Glorietta	21	15		6	12	3							2 (S)
13	Magda	32	7		25		1	3	2	1				4 (S)
14	Panamera	10	4		5	1	2	1						3 (S)
15	Nandina	16	7		9	2	3	2						3 (S)
16	Coronada	8	8			8								2 (S)
17	Cardinia	39	0		39									1 (R)
18	Captiva	22	6	3	13	3	1	2						2 (S)
19	Carlita	29	15		14	3			2			6	4	8 (S)
20	Florente	47	11		36	3	2	1	1			4		8 (S)
21	Jelly	40	9		31	4	3	2						2 (S)
22	Catania	6			6									1 (R)
23	Andrea	26	5		20	3	2	1						2 (S)
24	Leandra	33			33									1 (R)
25	El mundo	32	7	1	24	3	2	2						2 (S)
26	Red Fantasy	17	4		13	2	1	1						2 (S)
27	Pekaro	71	15	15	56	8	5	2						2 (S)
28	Lileya	37	17	5	15	9	1			2	5			2 (S)
29	Skrab	39	39			18				2	15		4	2 (S)
30	Saturna	362	79	128	283	24	18	14	10	5		4	4	2 (S)
31	Briz	321	49		272	19	13	12	2	3				2 (S)
32	Uladar	69	24		45	11	5	4	2	2		1		2(S)
33	Javakheturi	23	18		5	7	6	1			1		3	2 (S)
34	Meskhuri	45	15		30	4	5	3	2	1				3 (S)

The results of all trials are summarized in Table 4. According to screening results, the main parts of evaluated cultivars (82.9%) were susceptible to wart in all trials. Based on a comparison of the results obtained in this study, the Belarusian cultivars Lileya, Briz, Uladar, Scrab, the Datch cultivars Saturna, Marfona, Estela, Alwara and the cultivars Javakheturi and Meskhuri selected from breeding materials of International Potato Center (CIP) were susceptible in the pot test as well as both field assays. However, we observe that some cultivars differed in their response to potato wart population with a different origin, so, they were resistant in one location but susceptible in another.

Table 4. *Reaction of cultivars to PW using field and pot tests in Khulo Municipality*

N	Cultivars	Pot Test	Disease rating in the field test (scale 1–9)*	
		Didajara (2016)	Skvana (2017)	Uchkho (2018)
1	Marfona	S	S	S
2	Sylvana	S	R	S
3	Marabel	S	R	S
4	Europrima	S	-	S
5	Bernadette	S	-	S
6	Figaro	S	-	S
7	Agria	S	R	S
8	Artemis	S	-	S
9	Skrab	S	S	S
10	Estela	S	S	S
11	Alwara	S	S	S
12	Omega	R	Missing	Missing
13	Glorietta	S	S	S
14	Magda	-	-	S
15	Panamera	S	-	S
16	Nandina	S	-	S
17	Coronada	-	-	S
18	Cardinia	-	-	R
19	Captiva	-	-	S
20	Carlita	-	-	S
21	Florente	-	-	S
22	Jelly	S	-	S
23	Sante	S	-	-
24	Catania	-	-	R
25	Andrea	-	-	S
26	Leandra	-	-	R
27	El mundo	-	-	S
28	Red Fantasy	-	-	S
29	Lileya	-	S	S
30	Spunta	S	-	R
31	Pekaro	S	-	S
32	Saturna	S	S	S
33	Briz	S	S	S
34	Uladar	S	S	S
35	Impala	S	S	-
36	Laura	S	S	-
37	Arnova	R	-	-
38	Sofia	R	-	-
39	Annalena	S	-	-
40	Arizona	R	-	-
41	Fabula	R	-	-
42	Caruso	R	-	-
43	Finca	S	-	-
44	Arinda	R	-	-
45	Milva	S	-	-
46	Javakheturi	S	-	S
47	Meskhuri	-	S	S
48	Meskhuri tsiteli	S	Missing	Missing

As above mentioned, the cultivars Agria, Sylvana and Marabel originating from the Netherlands reported to be resistant to potato wart, pathotype D1 [21], were also resistant in the field in Skvana village. However, they showed the susceptible reaction to wart (4 diseased tubers with 4 clases) in the field test conducted in Uchkho village and in the pot test.

In the study conducted in Turkey, the cultivars Marabel and Agria showed the susceptible reaction to the pathotype 38 (Nevşehir) of potato wart [24, 25]. Concerning the susceptible reaction of these cultivars to the wart, our results are like because the pathotype 38 was identified in the isolates originated from Didajara village. Different reaction of cultivars to wart population from Skvana can be explained that perhaps another pathotype is spread in the Skvana village. Pathotype identification of wart isolates from Skvana and Uchkho villages have not been carried out yet.

Conclusion

To the best of our knowledge, the current study presents the first data on the level of resistance among some introduced potato cultivars to wart using pot and field tests in the three locations of Khulo municipality.

Based on the results obtained in this study, most of the tested potato varieties currently being grown in Khulo should be withdrawn from commercial production due to their susceptible reaction to the wart. Several cultivars (Omega, Arnova, Sofia, Arizona, Fabula, Caruso, Arinda) showed resistance to the disease using pot test, the cultivars Catania, Leandra, and Cardinia were resistant in the field tests of Uchkho and the cultivars Sylvana, Marabel and Agria showed the resistance in Skvana field test. However, they cannot be recommended for growing in Khulo district because it is also necessary to assess the degree of resistance of these varieties using laboratory methods to confirm the results obtained in the future.

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References

[1] Geostat Average Yield of Annual Crops. http://www.geostat.ge/index.php?Action=page&p_id=428&lang=eng, 2017.

[2] K. Schilberszky, A new parasite causing potato wart disease (in German), Ber Dtsch Bot Ges., 14 (1896) 36–37.

[3] K. M. Curtis, The Life-History and Cytology of Synchytrium endobioticum (Schilb.), Perc., the Cause of Wart Disease in Potato, Philosophical transactions of the Royal Society of London., Series B, Biological sciences, 1921 84-95.

[4] I.M. Smith, D.G. McNamara, P.R. Scott, M. Holderness, B. Burger, Qurantine pests for europe. Data sheets on quarantine pests for european Union and for the european and Medterranean Plant Protection Organisation**,** 2nd ed.,. CAB International, wallingford, 1997.

[5] EPPO (European and Mediterranean Plant Protection Organization), online. EPPO Global Database. Available online: https://gd.eppo.int (Accessed on 02 May 2018)

[6] L. Gorgiladze, G. Meparishvili, Z. Sikharulidze, K. Natsarishvili, S Meparishvili, First report of Synchytrium endobioticum causing potato wart in Georgia, New Disease Reports. 30 (2014) 4.

[7] S. Ghoghoberidze, Z. Sikharulidze, G. Meparishvili, L. Gorgiladze, S. Meparishvili, Ts. Tsetskhladze, Occurrence of Potato Wart in Georgia. Book Of Proceedings, IX International Scientific Agriculture Symposium “AGROSYM 2018”, (2018) 876-880.

[8] G. Frank, Potato wart. APSnet Features. http://www.apsnet.org/publications/apsnetfeatures/pages/potatowart.aspx, 2007.

[9] Anon, EPPO Standards. Synchytrium endobioticum: diagnostic protocols for regulated pests, OEPP/EPPO Bull., 34 (2004) 213–218.

[10] J. Przetakiewicz, The viability of winter sporangia of Synchytrium endobioticum (Schilb.) Perc. from Poland, American Journal of Potato Research, 92 (2015) 704–708.

[11] EPPO, EPPO Standards PM 3/59 (3) Synchytrium endobioticum: soil tests and descheduling of previously infested plots, OEPP/EPPO Bull., 47 (2017) 365–367.

[12] M. C. Hampson, History, biology and control of potato wart disease in Canada, Can J Plant Pathol. 15 (1993) 223–244.

[13] R. Baayen, G. Cochius, H. Hendriks, J. Meffert,

M. Bekker, P. van den Boogert, H. Stachewicz, G. van Leeuwen, History of potato wart disease in europe—a proposal for harmonisation in defining pathotypes, eur J Plant Pathol. 116 (2006) 21–23.

[14] E. Çakir, G.C.M. van Leeuwen, K. Flath, J.P. Meffert, W.A.P. Janssen, S. Maden, Identification of pathotypes of Synchytrium endobioticum found in infested fields in Turkey, OEPP/EPPO Bull. 39 (2009) 175–78.

[15] J. Przetakiewicz, First report of new pathotype 39 (P1) of Synchytrium endobioticum causing potato wart disease in Poland. Plant Dis., 99 (2015) 28-35.

[16] J.E. Obidiegwu, K. Flath, C. Gebhardt, Managing potato wart: a review of present research status and future perspective, Theor. Appl. Genet. 127 (2014) 763–80.

[17] Z. Sikharulidze, S. Ghoghoberidze, G. C. M. van Leeuwen, N.M. Mentink, G. Meparishvili, Ts. Tsetskhladze, Pathotypes of Synchytrium endobioticum, causal agent of potato wart disease, present in Georgia. OEPP/EPPO Bull. (2018) [in press].

[18] C. Bragard, D. Caffier, T. Candresse, E.Chatzivassiliou, K. Dehnen-Schmutz, G. Gilioli, J.C. Grégoire, J.A.J.Miret, M. Jeger, A. MacLeod, M.N. Navarro, B. Niere, S. Parnell, R. Potting, T.Rafoss, V. Rossi, G.Urek, A.van Bruggen, W. V. der Werf, J. West, S. Winter, Pest categorisation of Synchytrium endobioticum, EFSA Journal,2 (2018) 75-85

[19] Anon, Ordinance of the Government of Georgia N 305. Technical Regulations on Approval of Potato Wart Control. https://matsne.gov.ge/en/document/view/2887201 , (2015).

[20] L. Dimitrova, M. Laginova, A. Becheva, G.C.M. van Leeuwen, Occurrence of potato wart disease (Synchytrium endobioticum) in Bulgaria, OEPP/EPPO Bull. 41(2) (2011) 195–202.

[21] The Netherlands catalogue of potato varieties. The Netherlands potato consultative foundation. http://www.aardappelpagina.nl/files/Netherlands_catalogue_of_potato_varieties_2011_Nivap.pdf, 2011.

[22] The European Cultivated Potato Database. http://www.europotato.org/

[23] EUROPLANT Pflanzenzucht GmbH. https://www.europlant.biz/fileadmin/db_upload/Catania_E_2016-06.pdf

[24] H. Naçti, A. Erkiliç, Determination of Variety Reaction to Potato Wart Disease (Synchytrium endobioticum) in Potato Planting Areas of Nevsehir Province, Turkey. J. Turk. Phytopath. 39 (2010) 39-44.

[25] E. Cakir, H. Onaranz, H. Duran, M.G. Bilglnz, Reactions of commercial potato cultivars against wart disease and effect of the disease on yield in Turkey (in Turkish). 2006 https://www.researchgate.net/profile/Emel_Cakir/publication/275177764_TURKIYE'DE_TICARI_PATATES_CESITLERININ_SIGIL_SYNCHYTRIUM_ENDOBIOTICUM_SCHILB_PERC_HASTALIGINA_REAKSIYONLARI_VE_HASTALIGIN_VERIME_ETKISI_Reactions_of_commercial_potato_cultivars_against_wart_disease_an/links/55349f260cf20ea0a076bd77/TUeRKIYEDE-TICARI-PATATES-CESITLERININ-SIGIL-SYNCHYTRIUM-ENDOBIOTICUM-SCHILB-PERC-HASTALIGINA-REAKSIYONLARI-VE-HASTALIGIN-VERIME-ETKISI-Reactions--of-commercial-potato-cultivars-against-wart-disease-an.pdf

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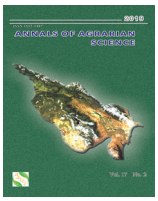

The materials on citrus mycobiota research

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A B S T R A C T

In this paper the results on citrus fruit mycobiota research are presented. The following citrus varieties are widely spread in the humid subtropical climate zone of Western Georgia, on the Black Sea coast: lemon, mandarin, orange and grapefruit. The favorable climatic conditions for fruit development promote the development of various fungal diseases as well, including the diseases of the fruit. The aim of the present research was to study the mycobiota of citrus fruits and to determine the causal agent of disease – the pathogenic fungi. For the identification of fruit mycobiota the isolation of fungi in pure culture from the lesion fruit were performed in the test-tubes and onto the Petri dishes. The identified by us 15 species of fungi include the following: *Rhizopus nigricans* E., *Fusarium lateritium* Nees, *F. limonii* Br., *Penicillium italicum* Wehmer, *P. Digitatum* Sacc., *Aspergillus niger van. Tiegh., Trichoderma lignorum* Tode, *Botrytis cinerea* Pers., *Alternaria citri* Pierce, *Colletotrichum gloeosporioides* Penz., *Sphaceloma fawcettii* Jenk. *(Elsinoe fawcettii* Bitancourt &Jenk.*)*, *Phoma citricarpa* Mc. Alpine, *Ph. limonis* Thum and *Phomopsis citri* Faw. The Fungus *Aternaria citri* differs from above listed by the frequency of occurrence. Their diagnosis are provided below.

Keywords: *Citrus fruit, Fungal diseases, Mycobiota, Morphology, Identification. Diagnosis.*

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Introduction

Citriculture is one of the most important, leading commercial industries of agriculture of Georgia. Citrus plants belong to the subtropical fruit tree cultures. Mandarin ranks the first in Georgia by the spreading and producing products, lemon – the second and orange – the third. Citrus fruits are distinguished with nutritional value, dietary, medicinal properties and palatable taste. They contain a large number of different vitamins (C, D, B, PP) carotene (provitamin A), sugars, organic acids, pectin, mineral salts. Citrus fruits are used as raw and as well as processed in the form of fruit jam, candied fruit, marmalade, soft drinks, compote, and they are widely used as well as in confectionery, pharmacology, perfumery (fruit skin, leaves, flowers) and culinary (for production of essences, essential oils, pectin).

The favorable climatic conditions for the development of citruses on the Black Sea coast (humid climate of Western Georgia, periodic frosty winters) promote the development of diseases, which should explain the abundance of mycobiota's representatives in the Black Sea coastline to a number of agricultural crops, including citrus plants.

Numerous researches were conducted on mycobiota of citrus fruit crops in Georgia. N. Voronikhin detected 26 species of fungi of citrus fruits even in 1937 [1].

P. Nagorni with co-authors has conducted a thorough study of citrus mycobiota. They have identified 38 species of fungi, which are spread on citrus branches, leaves and fruit [2].

L. Tsereteli and N. Chanturia have noted 30 species of fungi on citrus fruits [3].

K. Gikashvili has revealed the following genus of fungi on citrus fruits *Phytophthora, Sphaceloma, Colletotrichum* and *Botrytis* [4].

L. Beradze with the co-authors has mentioned the following types of fungi on citrus fruit: *Elsinoe fawcettii, Glomerella cinguata, Botryotinia fuckeliana, Phytophthora citrophthora* and *Alternaria citri* [5].

Foreign researchers have identified different types of fungi on citrus fruits: *Colletotrichum gloeosporioides, Penicillium italicum, P. digitatum,*

Aternaria citri, Mycosphaerella citri, Diaporthe citri, Elsinoe fawcettii, Elsinoe australis, Septoria sp., Aspergillus sp., Phytophthora palmivora, Sclerotinia sclerotiorum, Botryris cinerea, Botryosphaeria rhodina, Trichoderma sp. and etc. [6, 7].

Objectives and Methods

The citrus fruits (lemon, mandarin, orange), lesion by fungal diseases represented the research object.

The aim of the present research was to study the mycobiota of citrus fruits and to determine the causal agent of disease – the pathogenic fungi. Laboratory investigations were conducted in the LEPL Laboratory of the Ministry of Agriculture of Georgia.

For the identification of fruit mycobiota the isolation of fungi in pure culture from the lesion fruit were performed in the test-tubes and onto the Petri dishes. The Wort Agar was used as or the growth and development of fungi. The cultivation of fungi occured in an incubator at 20-25^0 C temperature. The microscopic analyses of isolated cultures was performed every 3-5 days, prior to the development of fruiting bodies of fungi. For the identification of fungi were used the corresponding Guides of Fungi [8-14].

Results and Discussion

As a result of our studies, a total of 15 species of fungi is identified from the lesion citrus fruits, belonging to the following classes - *Zygomycetes, Ascomycetes and Deuteromycetes* and orders - *Mucorales* or molds, *Dothydiales, Hyphales*, *Melaconiales* and *Sphaeropsidales*. Their diagnoses are given below.

Rhizopus nigricans E.

Mandarin peel with watery spots, covered with white plaque, were placed in the Petri dishes. This white plaque later turned dark gray. The colony is fast-growing, with loose-felty texture, olive-brown-gray in color, hyphaes and stolons have developed, which are differentiated as rhizoids and stylosporangiophores. Rhizoids are branched and dark brown in color. Stylosporangiophores deployed in stolon's nodes in groups in number of 2-5 are almost black; stylosporangiophores within the size of 500-3000×10-35 μm, stylosporangium 80-150 μm in diameter, columella 50-120 μm in diameter. The sporangiospore (Fig.1) ellipsoidal-spherical shaped, 4-12×4-10 μm in diameter [8].

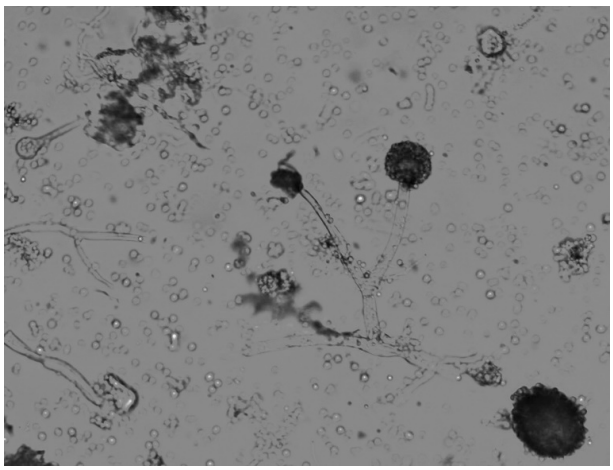

Fig. 1. *Sporangium and sporangiospores of Rhizopus nigricans E. (Mag. X20)*

Fusarium lateritium Nees.

Following inoculation of lesion mandarin fruit peel on the Wort Agar growth media, the tall, aerial, reddish-pink multicellular mycelium was developed, divided by septa. Macroconidia - sickle-shaped, colorless, multicellular, number of septa 2-5; spores (Fig.2) are within the size of 30-45.6×3.8-5.7 μm [9].

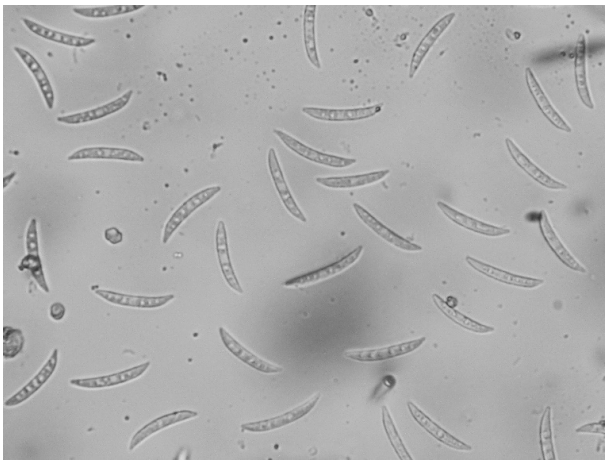

Fig. 2. *Spores of Fusarium lateritium Nees. (Mag. X40)*

Fusarium limoii Br.

Following inoculation of lesion mandarin and lemon fruits in tube on Wort Agar the low, cotton-like, whitish-pinkish multicellular mycelium has developed, spores sickle-shaped, colorless, multicellular, number of septa 1-3; spores are within the size of 12.5-30.4×3.4-4.9 μm [9].

Penicillium italicum Wehmer.

The white mycelium was developed on mandarin fruit peel following incubation on a wet-chamber, afterwards on which the blue, loose plaque appeared - the fruiting bodies of fungi. The fruit tissue is softened, watery. The microscopic analysis has shown that, mycelium is branched, colorless, with well-defined septa; conidiophores are of the various forms and standing in upright position, at the end of which one or two tiers of sterigmata are developed, on which the chain of spores are (Fig.3) created. The spores are colorless, single-celled, and roundish, within the size of 4.2-5.5×2.5-3 μm [10].

Fig. 3. *Conidiophores and spores of Penicillium italicum Wehmer (Mag. X40)*

Penicillium digitatum Sacc.

The white mycelium was developed on mandarin fruit peel following incubation in a wet- chamber, afterwards the dark yellowish-green color plaque appeared on warty spots, which is edged with the wide, white lace. Conidiophores are branched, at the tip of the branches sterigmata are observed located in ring. Conidia of an ovoid shape is seen, some of them cylindrical, single celled, colorless, within the size of 6.2-8×4.5-5 μm [10].

Aspergillus niger van.Tiegh.

The softened, mandarin and lemon peels, with watery spots, on which at first white and afterwards black loose plaque developed, were placed on Potato-Dextrose Agar (PDA) in the Petri dishes. After 5 days of incubation at 25^0 C the colony growth till 43-60 mm was observed. The mycelium surface was velvety and smooth, on that conidiophores have developed within the size of 200-400×7-10 μm. They are prolonged, divided by septa, clavate, with spherical thickened section part on the tip 20-50 μm in diameter, covered with radially constructed pro phialide of 6-100 μm long and phialide of 20-30 μm long. On phialide one after another single celled brown conidia (Fig.4) developed in chains 3-5 μm in diameter. The taller conidia is of the chain, the bigger is it in size, intensely colored and matured [7].

Fig. 4. *Conidia of Aspergillus niger van. Tiegh. (Mag. X20)*

Trichoderma lignorum Tode

Following inoculation of affected mandarin fruit peel spots in tube on the Wort Agar, the dark yellowish-green color mycelium was developed, that is low, felt like, wavy, multicellular; the conidiophores (Fig.5) are highly branched, at the tips of which the heads appeared, created from conidiospores. The conidium are spherical, dark yellow-green color, single celled, within the size of 3.7×4.5 μm [10].

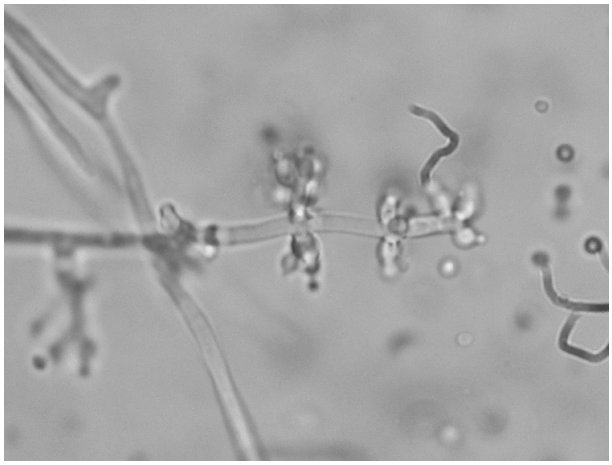

Fig. 5. *Conidiophores and phialides of Trichoderma lignorum Tode (Mag. X40)*

Botrytis cinerea Pers.

Mandarin and lemon peels, with the red-brown lesions, were placed in the Petri dishes. Following some days greyish mycelium appeared on spots with the well developed dense, felty texture. Conidiophores (Fig.6) are branched tree-like, in upright position, on their top rows the conidia are developed in groups of 8-10 pieces. The spores are ellipsoidal-spherical, colorless, 4-11×6-18 μm in diameter [7].

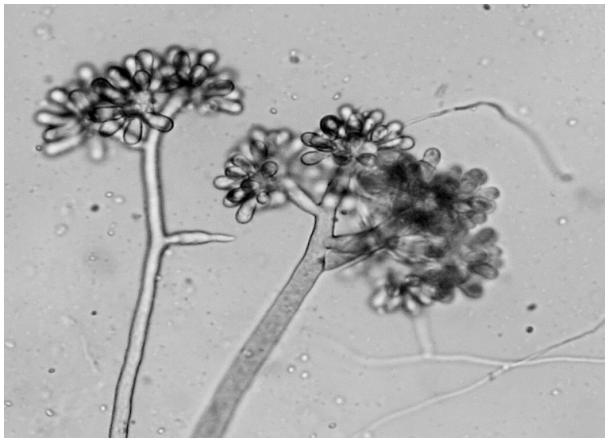

Fig. 6. *Conidiophores and spores of Botrytis cinerea Pers. (Mag. X40)*

Alternaria citri Pierce

Following inoculation of lesion mandarin and lemon fruits on the Wort Agar the dark grayish-blackish, low mycelium developed. The fruiting bodies of fungi are developed on the tube walls in the form of the black spots. Conidiophores are brown, short; spores (Fig.7) prolonged, bottle-shaped, brown, with transverse and longitudinal septa. The number of longitudinal septa is 1-3, transverse - 2-6, spores are within the size of 15.2-49.4×11.4-12 μm [11].

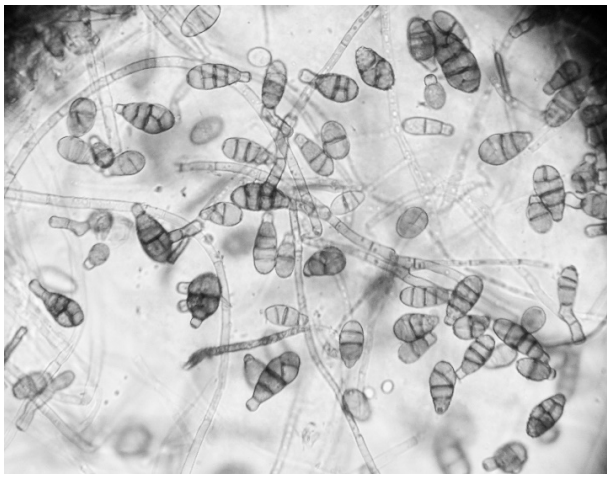

Fig. 7. *Spores of Alternaria citri Pierce (Mag. X40)*

Colletotrichum gloeosporioides Penz.

By the two weeks of incubation in a wet-chamber the mandarin fruit became covered with whitish mycelium. The warty spots of orange color (the fruiting bodies of fungi - acervuli) developed on the peel. Spores (Fig.8) are single celled, ellipsoidal, colorless, within the size of 10.2-20×5-6 μm [12].

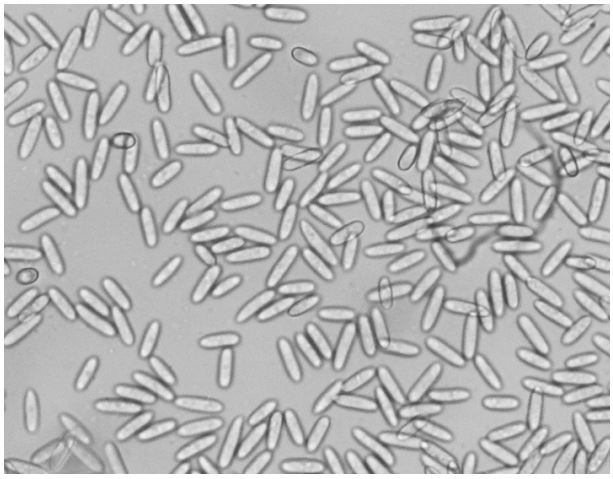

Fig. 8. *Spores of Colletotrichum gloeosporioides Penz. (Mag. X40)*

Sphaceloma fawcettii Jenk. (anamorph); *Elsinoe fawcettii* Bitancourt &Jenk. (telemorph)

Mandarin and lemon fruits peels, with watery spots, were placed on agar medium in the Petri dishes. Colony is slow growing, from pink to violet. Ascomata is pad-like, ellipsoidal, dark colored, pseudoparenchimal, multichambered, thickness - up to 80-120 μm, up to 20 asci in each chamber. An ascus spherical in shape or egg shaped, 12-16 μm, is enclosed in a double wall, inner wall is thickened to the tip, with 8 ascospores, which are transparent, ellipsoidal or prolonged-ellipsoidal, from two to four cells. Typically, is stretched in the mid region of septa, 10-12×5-6 μm.

The acervuli inner epidermal or sub-epidermal (half epidermal), pseudoparenchimal. The conidiophores cells are generated from the upper pseudoparenchimal cells or pale brown phialide conidiophores, which consist of 2-4 septa, up to 12-22×3-4 μm in size. The mycelium is colorless, poorly developed, septated, short branched. Spores are colorless, single celled, ellipsoidal, bulging, 5-7×2-5 μm [7; 13].

Phoma limonis Thum.

For the 10th days of incubation in a wet-chamber, the white, aerial mycelium was developed, which entirely covered the fruit. The dark black spots are developed on peel – pycnidia, that represent the fruiting bodies of fungi. Pycnidia are 70-210 μm in diameter. Spores are colorless, single celled, round, within the size of 1.9-3.8X1.5-3 μm [12].

Phoma citricarpa Mc. Alpine

The various black spots were developed on the peel of lemon - pycnidia, which represent the fruiting bodies of fungi. The pycnidia (Fig.9) are dark brown, rounded, with well defined porus, with 70-250 μm in diameter. The spores are single celled, colorless, ovoid, within the size of 7.5-13×5-7 μm [14].

Fig. 9. *Pycnidia and spores of Phoma citricarpa Mc. Alpine (Mag. X20)*

Phomopsis citri Faw.

Following inoculation of lesion mandarin fruit on the Wort Agar the low, white, cotton like, multicellular mycelium developed. The fruiting bodies of fungi - pycnidia are ovoid, with well defined porus, 100-350 μm in diameter. The pycniospores (α conidia) are spindle-shaped, colorless, single celled, within the size of 3.7-11.4×2.6-3.8 μm (Fig.10). Stylospores (β conidia) are thread-like, hook-shaped, colorless, within the size of 18-25 μm [15].

Conclusion

The diseases of citrus fruit (lemon, mandarin, orange) are widespread in the humid subtropical climate zone of Western Georgia, on the Black Sea coast and are characterized by a great harmfulness.

15 species of fungi are identified from the citrus fruit, affected by fungal disease, which belong to the class of *Zygomycetes, Ascomycetes* and *Deuteromycetes*; *Mucorales* or to the order of molds, *Dothydiales, Hyphales*, *Melaconiales* and *Sphaeropsidales*: *Rhizopus nigricans* E., *Fusarium lateritium* Nees*, F. limonii* Br., *Penicillium italicum* Wehmer., *P. digitatum* Sacc., *Aspergillus niger van. Tiegh., Trichoderma lignorum* Tode, *Botrytis cinerea* Pers., *Alternaria citri* Pierce, *Colletotrichum gloeosporioides* Penz., *Sphaceloma fawcettii* Jenk. *(Elsinoe fawcettii* Bitancourt &Jenk.*)*, *Phoma citricarpa* Mc. Alpine, *Ph. limonis* Thum and *Phomopsis citri* Faw. From the above stated, the fungus *Alternaria citri* Pierce differs by the frequency of occurrence.

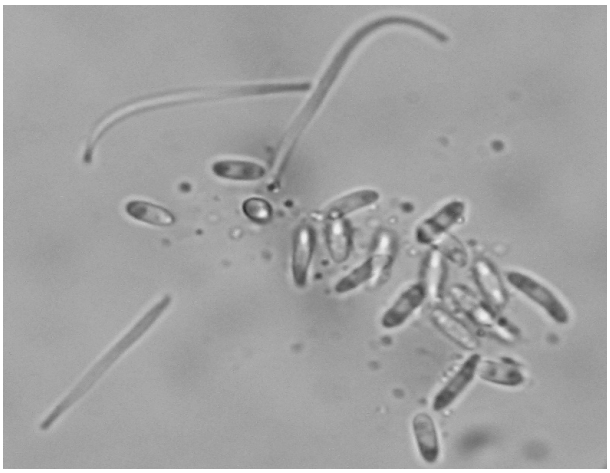

Fig. 10. *Spores (α and β) of Phomopsis citri Faw. (Mag. X40)*

References

[1] N. N. Voronikhin, Fungal and Bacterial Diseases of Citruses, Publishing house of Academy of Sciences of the USSR, Moscow-Leningrad, 1937.

[2] P.I. Nagorni, K.G. Gikashvili, N.A. Sakvarelidze, Materials on Mycoflora of Citrus Culture of Georgia SSR, Ganatleba, Tbilisi, 1940.

[3] L. J. Tsereteli, N. N. Chanturia, Diseases of Citrus Fruit at Storage and Measures of Fight Against Them, Ganatleba,Tbilisi,1940.

[4] K. G. Gikashvili, Culture Diseases and Measures of Fight Against them, Sakhelgami, Tbilisi, 1952.

[5] L.A. Beradze, E. Sh. Djakeli, N.A. Motskobili, G.R. Memarne, Pathogenic fungi on citrus fruits in Western Georgia, The first International Transcaucasus Conference on Phytopathology. Theses of reports, Tbilisi, Georgia, September 25-27 (2008) 51-52.

[6] Paula F. Tennant, Dwight Robinson, Latanya Fischer, Stacy-Marie Bennent, Dave Hutton, Phillis Coates-Beckford, Wayne Mc Laugh-

lin, Diseases and Pests of Citrus (Citrus spp.),http://www.globalsciencebooks.info/Online/GSBOnline/images/0906/TFSB_3(SI2)/TFSB_3(SI2)81-107o.pdf, 2009.
[7] L. W. Timmer, S. M. Garnsey, J. H. Graham, Compendium of Citrus Diseases, second ed., St. Paul, 2000.
[8] V. I. Bilay, Microorganisms - Causative Agents of Diseases of Plants, Naukova Dumka, Kiev, 1988.
[9] A. A. Jachevsky, Guide of Fungi (Sac fungi), second ed., Petrograd, 1917.
[10] N. M. Pidoplichko, Fungi – Parasites of Cultural Plants, Naukova Dumka, Kiev, 1977.
[11] P. A. Saccardo, Sylloge Fungorum Omnium Hucusque Cognitorum, vol. XVIII, Berlin, 1906.
[12] P. A. Saccardo, Sylloge Fungorum Omnium Hucusque Cognitorum, vol. III, Berlin, 1884.
[13] Elsinoë fawcettii and Elsinoë australis, Prepared by CABI and EPPO for the EU under Contract 90/399003 Data Sheets on Quarantine Pests. https://gd.eppo.int/download/.../649_ds_ELSISP_en.pdf, 1990.
[14] P. A. Saccardo, Sylloge Fungorum Omnium Hucusque Cognitorum, vol. XVI, Berlin, 1902.
[15] H. A. Fawcett, Citrus Diseases and Their Control, London, 1936.

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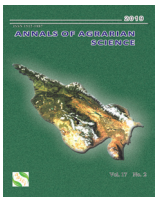

Simulation of dust convective transfer of Zestafoni ferroalloy plant

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A B S T R A C T

Kinematics of aerosols propagation emitted into the atmosphere from aeration lanterns of gas-trapping units of workshops No. 1 and No. 4 of Georgian Manganese LLC is studied using numerical integration of the system of three-dimensional non-linear non-quazistatic equations of thermal convection and admixture transfer-diffusion in the atmosphere. It is obtained through modeling that a kinematics of dust propagation emitted into the atmosphere significantly differs from each other in cases of calm air and background motions. During calm air a dust propagation is caused by a wind velocity field generated as a result of thermal convection. At this time wind velocity convergence zone is formed in the vicinity of aeration lanterns. This zone is gradually getting smaller with height increase and turns into divergence zone in the upper part of the surface layer of the atmosphere. Ascending convective air and dust stream is obtained above each source. Vertical velocity formed as a result of convection process reaches 5 m/s. Horizontal components of wind velocity in divergence and convergence zones don't exceed 3 m/s. In case of background wind a dust is propagated as a result of both ordered (vented) horizontal and vertical streams, and small-scale vortex and diffusive motions. Advective, convective and turbulent dust diffusion under the influence of background motions forms the vertically inclined trail-like pollution zone. There is no place of vortex motion in the obtained zone.

Keywords: Atmosphere, Dust, Pollution, Simulation, Convection, Stationary sources

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Introduction

Modeling of atmospheric air anthropogenic polluton in the industrial centers, study of peculiarities of its spatial and time distribution is one of the topical problems related to human health and environment protection. Polluting sources are numerous, their origination sources [1], transformation kinematics and propagation dynamics [2] are diverse. Respectively, the mathematical models describing wide range of the problem from local one to global-scale processes are multifarious, as well [3-5]. One of the research directions is a propagation of polluting ingredients from separate sources at the territories of local scale. Mathematical systems describing local propagation of ingredients, use semi-empirical methods, stationary or non-stationary Gaussian models or rest on numerical integration of Navier-Stocks's nonstationary nonlinear nonstatic equations on the high-definition numerical grid.

Empirical system of atmosphere pollution estimation became widely used in Georgia and post-Soviet countries [6,7]. It is used for assessment of environment pollution extreme level, maximum permissible exhausts and common pattern of contamination and doesn't reflect the local features of pollutions caused by separate sources.

The goal of the presented work is the development of a numerical model of transfer-diffusion of substances emitted from separate sources (on a grid with high-definition (1-100m) ability) on the basis of thermal convection equations and study by its means of local peculiarities of dust propagation emitted in an orderly way into the atmosphere from Georgian Manganese LLC ferroalloy plant.

Research methods and ways of solution

System of equations of hydrothermodynamics, describing the propagation of meso-scale (≈1 km) atmospheric processes and agents emitted from separate sources into a dry atmosphere, can be written as follows [8, 9]:

$$\frac{du'}{dt} = -\frac{\bar{p}}{\bar{\rho}}\frac{\partial \varphi'}{\partial x} + l_z v' - l_y w' + \mu \Delta u' + \frac{\partial}{\partial z}\nu\frac{\partial u'}{\partial z},$$

$$\frac{dv'}{dt} = -\frac{\bar{p}}{\bar{\rho}}\frac{\partial \varphi'}{\partial y} - l_z u' + \mu \Delta v' + \frac{\partial}{\partial \zeta}\nu\frac{\partial v}{\partial \zeta},$$

$$\frac{dw'}{dt} = -\frac{\bar{p}}{\bar{\rho}}\frac{\partial \varphi'}{\partial z} + g\vartheta' + l_y u' + \mu \Delta w' + \frac{\partial}{\partial z}\nu\frac{\partial w'}{\partial z},$$

$$\frac{\partial u'}{\partial x} + \frac{\partial v'}{\partial y} + \frac{\partial w'}{\partial \zeta} = 0,$$

$$\frac{d\vartheta'}{dt} + Sw = \mu \Delta \vartheta' + \frac{\partial}{\partial z}\nu\frac{\partial \vartheta'}{\partial z}$$

$$\frac{dC'}{dt} - w_c\frac{\partial C}{\partial z} = \mu \Delta C' + \frac{\partial}{\partial z}\nu\frac{\partial C'}{\partial z},$$

$$\text{Operators } \frac{d}{dt} = \frac{\partial}{\partial t} + \operatorname{div}(V\cdot), \Delta = \frac{\partial}{\partial x^2} + \frac{\partial}{\partial y^2},$$

(1)

where t – time, x, y and z – coordinates of axes directed to the east, north and upward vertically, p – pressure, ρ - density, T – temperature, V – wind velocity vector, which components along x, y and z axes are u, v, and w.

Meteorological figures are presented in the form of the sum of standard, background values and deviations from background values:

$$p = \bar{p} + \tilde{p} + p', \quad \rho = \bar{\rho} + \rho', \quad T = \bar{T} - \gamma z + \tilde{T} + T',$$

$$C = \tilde{C} + C', \quad u = \tilde{u} + u', \quad v = \tilde{v} + v', \quad w = \tilde{w} + w'.$$

A line "¯" means that a physical value corresponds with standard atmosphere, undulating line "~" reflects a corresponding (background) value of large-scale atmospheric process, while dash line " ′ " shows that a physical value presents deviation from background value and characterizes local atmospheric processes, at that

$$\frac{p'}{\bar{p}} << 1, \ \tilde{\varphi} = \frac{\tilde{p}}{\bar{p}} << 1, \ \varphi' = \frac{p'}{\bar{p}} << 1 \ \frac{\rho'}{\bar{\rho}} << 1, \ \tilde{\vartheta} = \frac{\tilde{T}}{\bar{T}} << 1, \ \vartheta' = \frac{T'}{\bar{T}} << 1.$$

$$\varphi' - \vartheta' = \frac{\rho'}{\bar{\rho}}, \ \bar{p} = \bar{p}(z), \ S = (\gamma_a - \gamma)/\bar{T}, \ \bar{T} = 300K.$$

γ_a is a dry-adiabatic gradient of temperature, γ – vertical gradient of background atmospheric temperature. μ and l_y are kinematic coefficients of horizontal and vertical turbulence, l_y and l_z – y and z components of Coriolis parameter.

The equation system is taken on the assumption that background wind velocities satisfy the geostrophic wind equations and we can neglect in the first approximation their horizontal and vertical changes in the local area: $\tilde{u} = \text{const}, \tilde{v} = \text{const}, \tilde{w} = 0$. The system (1) is defined in the time interval $0 \le t \le T$ and spatial area $\omega\{0 \le x \le X \ 0 \le y \le Y \ 0 \le z \le Z\}$. Let's attach initial

$$u' = v' = w' = \vartheta' = C' = 0 \text{ when } (x, y, z) \notin \Omega_1 \text{ and } t = 0,$$
$$u' = v' = 0, w' = w_0, \vartheta' = \vartheta_0, \ C' = C_0 \text{ when } (x, y, z) \in \Omega_1 \text{ and } t = 0$$

(2)

$$(u', v', w', \vartheta', \varphi', C')_{x=0} = (u', v', w', \vartheta', \varphi', C')_{x=X},$$

$$(u', v', w', \vartheta', \varphi', C')_{y=0} = (u', v', w', \vartheta', \varphi', C')_{y=Y} \quad (3)$$

$$(u', v', w', C')_{z=0} = (u', v', \vartheta', \varphi', C')_{z=Z} = 0,$$

$$\vartheta' = \vartheta_0', w' = w_0, \ C' = C_0 \ (x, y, z) \text{ when } (x, y, z) \in \Omega_1,$$

to the system (1) Ω_1 where is the area of dust atmospheric emission; $\vartheta_0(x, y, z)$, $w_0(x, y, z)$ and $C_0(x, y, z)$ are the temperature analogue, emission rate and dust concentration of the gas discharged into the emission area, respectively.

The system of equations (1) with conditions (2) and (3) is integrated according to implicit and explicit numerical scheme [8,9]. They are implemented on the numerical grid consisting of 81x81x51 points. Grid steps along x and y axes are 20 m, along z axis – 10m, and time step is 0,2 s.

Integration domain sizes are 1600 m x 1600 m x 500 m. The main facilities of Georgian Manganese LLC, from which the ordered emission of solid aerosols into the atmosphere occurs, are placed in this area. Fugitive emission of aerosols is not considered during modeling process. Aerosols size is taken as 10 μ. Their deposition rate is w_c =0,01 m/s.

According to the data obtained from Georgian Manganese LLC, solid aerosols are emitted from two main facilities of the enterprise, namely, from aeration lanterns of waste treatment facilities of workshops No. 1 and No. 4 equipped with hose filters. Basic characteristic values of emitted manganese dioxide are given in Table.

Table. *Basic characteristic parameters of dust emitted into the atmosphere and of its sources*

N	Height H (m)	Area S (m^2)	Gas-and-dust mixture temperature, T_0' (^oC)	Emission rate W_0 (m/s)	Concentration C_0 ($mg/m^{3)}$
Workshop No. 1	22	110	50	1	1,8
Workshop No. 4	42	440	31-63	1	5,4

Analysis of obtained results

Kinematics of dust emission into the atmosphere from two main sources of the ordered emission (workshops No. 1 and No. 4) of Georgian Manganese LLC (ferroalloy plant, Zestafoni) is studied through numerical experiments. Modeling was made for two meteorological situations: calm air and northwest wind, when wind velocity increases from 0 to 10 m/s, at 500 m height from the ground. In case of this direction a dust propagation emitted from both sources along one straight line and superposition of concentrations take place. Numerical modeling is conducted from the beginning of dust emission into the atmosphere to establishment of its quazi-stationary distribution – roughly within 0.5 hour.

Experiment I. Spatial distribution of dust concentration obtained through calculations during background calm air, when thermal convection is the main mechanism of dust propagationis is shown in Fig. 1 and 2. Concentration isolines are shown in the units of maximum permissible concentration (MPC = 0.5 mg/m^3). It is seen from this figure that after emission from gas-cleaning systems a dust is propagated in the atmosphere in the form of two vertical cylindrical streams independent from each other.

The basic dust mass (with concentration >0.1MPC) is distributed in the narrow area, which is getting wider and unites (gets together) approx. at 200-350 m height. Cylindrical column spread angle varies within the limits of 5-45°. At the higher levels a dust pollution cloud is of "mushroom"-like shape that is caused by origination of vertical vortex in the process of convection.

Concentration > 3 MPC is obtained directly above the emission site in 100-meter column. Concentration value 0.01-0.1 MPC is obtained at the significant territory of modeling area, at 10, 50m from the Earth surface and higher., We got low dust concentration 0.5-0.01 MPC close to the Earth surface, within 10 meters, around the waste treatment facilities of the workshop No. 1. In the vicinity of relatively higher waste treatment facilities of the workshop No. 4, dust concentration 0.1-0.01 MPC is obtained at substantially smaller area.

Spatial pattern of concentrations obtained through calculations is formed by velocity distribution peculiar for thermal convection (Fig. 2 and 3).

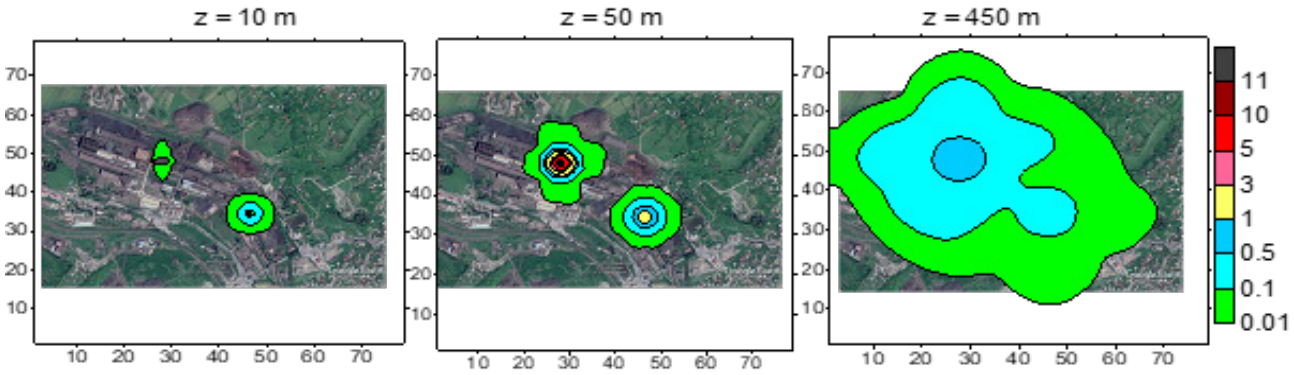

Fig. 1. *Dust concentration isolines in the atmosphere during calm air at 10, 50 and 450 m altitudes*

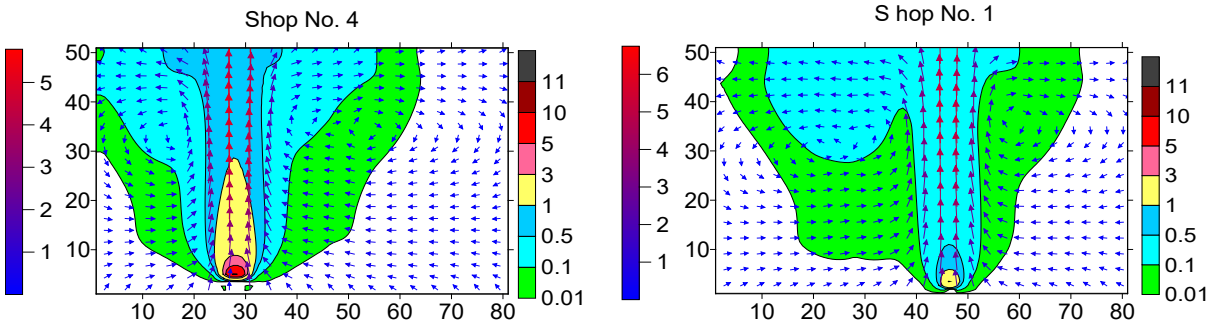

Fig. 2. *Dust concentration isolines and wind velocity vector projections in XOZ planes passing through treatment facilities*

It is seen from the figures that the emitted warm gas-and-dust mass causes development of thermal convection. Formation of a powerful vertical stream is peculiar for it. Clearly defined convergent zone is formed in the 350m thick stream layer, and intensification of vertical motion and dust transfer to the upper layer take place. Above 350 m air convergent stream gradually turns into divergent one, vertical velocity is getting smaller, wind is increased in horizontal direction and dust horizontal diffusion process is getting more intense. In the middle part of the modeling horizontal and vertical vortexes of wind velocity are formed, the unity of which creates a complex pattern of spatial annular stream. The maximum value of wind velocity 6 m/s is obtained in the convectional vertical stream.

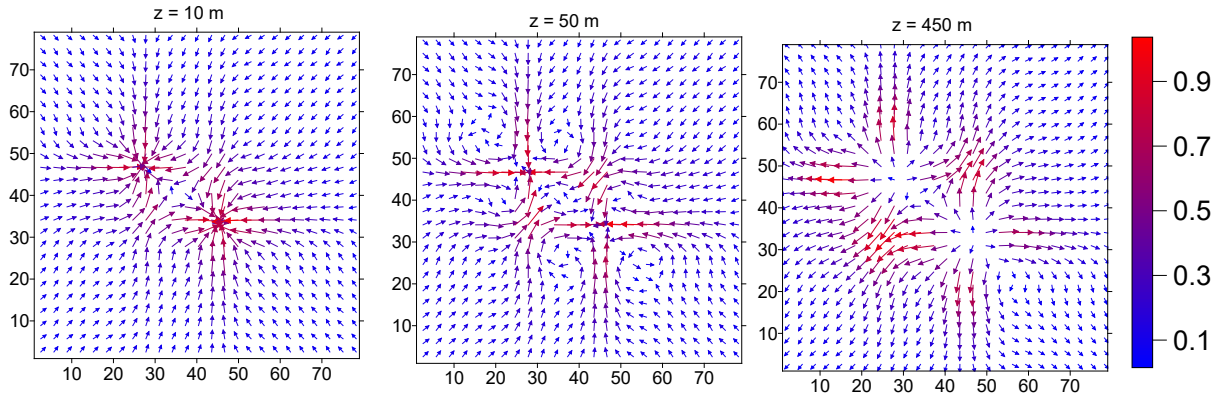

Fig. 3. *Dust concentration isolines and wind velocity vector projections in XOZ planes passing through treatment facilities*

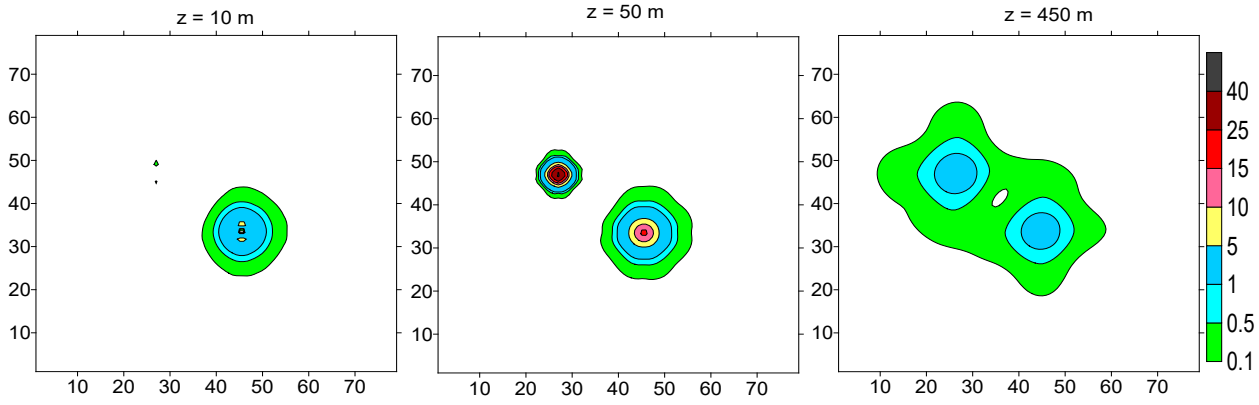

Fig. 3. *Temperature perturbation field at 10, 50 and 450 m altitudes resulted from convection*

Motion kinematics shows that a dust propagation in the central part of the modeling area occurs resulting from convective, advective, vortex processes and turbulent diffusion. The contribution of convective transfer and vertical turbulent diffusion in the vertical plane is roughly the same. In the horizontal plane a vortex turbulent diffusion prevails compared to an advective transfer. Gas emitted from waste treatment facilities changes atmosphere temperature in the vertical cylindrical area located near to the source (Fig. 4). Temperature change is minimal close to the earth and maximal in the vicinity of aeration lanterns. Warm air column penetrates through the space up to its upper limit. At the 450 m height a maximum value of ambient temperature perturbation reaches 5°C.

Experiment 2. Dust propagation emitted into the atmosphere from workshops No. 1 and No. 4 of the plant is modeled in case of north-west wind.

In Fig. 5 and 6 there is shown the dust concentration distribution at 10, 50 and 450 m altitudes. It is seen from the figures that a dust is transferred in south-east direction. In addition to the transfer, dust stream is getting wider and takes different shapes. Near the earth surface a pollution zone is located in the vicinity of aeration lanterns. Concentration value is small there and varies within a range of 0.01-0.5 MPC. Roughly at the 300 m distance from emission site, at 450 m height concentration reaches 0.5 MPC. At 50 m height a pollution cloud is of rectangular-like shape. Concentration maximums are located directly in the vicinity of emission site and are getting smaller both in the background wind direction and its perpendicular direction. The pattern different from classic dust propagation [11] is obtained in the central part of its stream at 50 m height, where a total concentration value created by both sources is equal to zero. The achieved effect is caused by the local ascendant motion generated during convective dust transfer (Fig. 6 and 7).

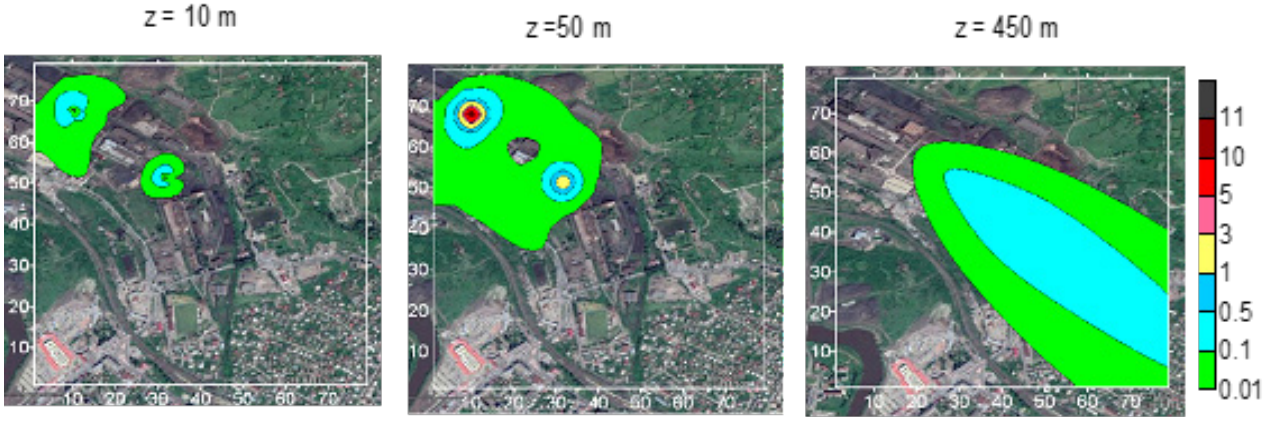

Fig. 5. *Dust atmospheric concentration isolines in the XOY plane at 10, 50 and 450m altitudes during background north-east wind*

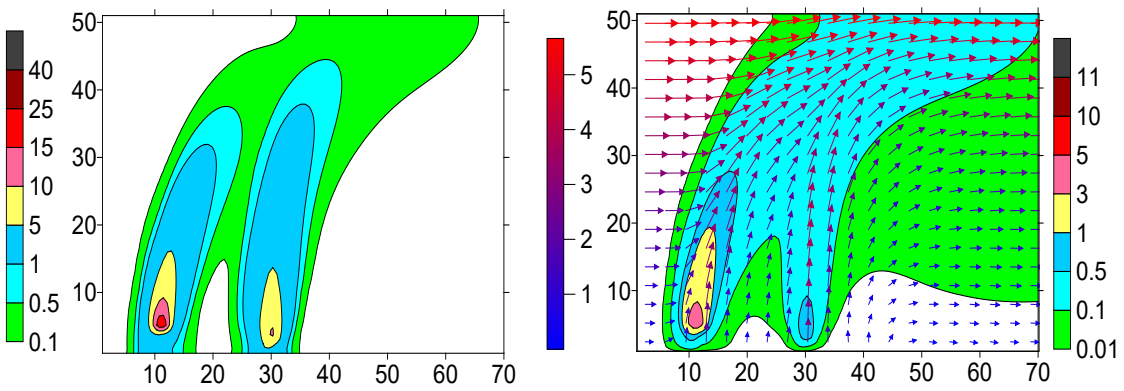

Fig. 6. *Distribution of temperature perturbation and dust concentration isolines, and wind velocity vector distribution along the vertical XOZ section directed along the background wind and passing through aeration lanterns of workshops No. 1 and No. 4*

It is seen from Fig. 6 and 7 that the development of thermal convection that is accompanied by warm gas-and-dust mass emission into the atmosphere, forms the horizontal convergent zone of wind velocity (Fig. 7) and powerful ascendant motion from the leeward side of emission (Fig. 6). Ascendant motion velocity significantly exceeds dust particle settling rate. As a result, at the distance more than 30 m from the source a dust convective transfer prevails over gravitational and turbulent depositions at the upper levels and it reduces near-the-ground pollution. In case of two sources, the combined action of two convective cells amplifies convective transfer effect and reduces dust settling on the underlying surface. As a result, an area of small dust concentration and area free of dust are formed near the ground.

In the upper layers baroclinic wind and established convective motions cause dust arc-shaped transfer in the vertical plane in the background motion direction.

In case of background wind, in contradistinction from calm air, local-scale horizontal and vertical vortexes don't generate. Respectively, a turbulent vortex dust diffusion has no place. A transfer is made as a result of convective and advective motions and gradient turbulent diffusion.

Conclusion

Carried-out numerical experiments revealed some peculiarities of dust local transfer that are not obtained when using wide-spread meso-scale and quazi-static models [2, 11]. In particular, they showed that thermal convection dynamics acts oppositely to turbulent diffusion and sedimentation processes, substantially reduces dust concentration in the vicinity of the source near to underlying surfaces of the atmosphere. In the vicinity of emission source the dust transfer from lower levels to higher ones and their subsequent advective propagation take place. Near the source and in the lower 300 m layer, during warm emissions and calm air situations, a dust vertical transfer is prevalent, while in the upper part – horizontal advective and turbulent transfers caused by divergent motion are dominant.

Dust concentration in the surface layers of the atmosphere is higher in case of baroclinic wind, than during background calm air. The mentioned effect is presumably caused by the increase in vertical turbulent transfer related to baroclinic motion.

It should be noted that obtained results are in qualitative agreement with the general, known from observation, results for emitted ingredients [12] (Fig.8) that can be used when performing a similar scientific research work taking into account the results of special experimental measurements.

Carried-out experiments showed that in order to specify the theory of dust local propagation it is necessary to investigate the number of issues, such as: impact of thermal and dynamic stratification, emission temperature and rate on convective and dust transfer processes etc.

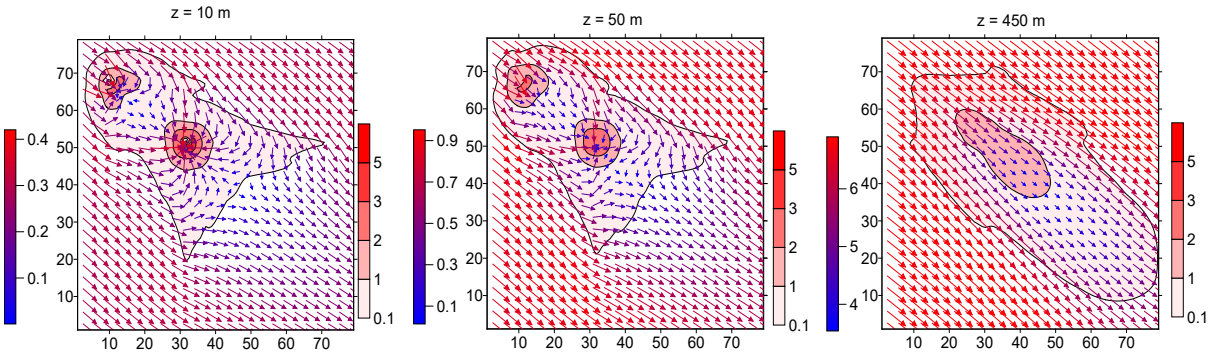

Fig. 7. *Distribution of wind velocity vertical component isolines and horizontal components at 10, 50 and 450 m altitudes*

Fig. 8. *Typical patterns of atmosphere pollution by separate sources*

Acknowledgment

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References

[1] Air pollution sources - Europian Environment Agency- europa EU. https://www.eea.europa.eu/themes/air/air-pollution-sources, 2019 (accessed 28.06.19).

[2] A.E.Aloyan, Modeling of dynamics and kinetics of gaseous admixtures and aerosols in the atmosphere, Nauka, Moscow, 2008 (in Russian).

[3] Wikipedia. Atmospheric dispersion modelling. https://en.wikipedia.org/wiki/Atmospheric_dispersion_modeling.

[4] Wikipedia. List of atmospheric dispersion models. https://en.wikipedia.org/wiki/List_of_atmospheric_dispersion_models, 2019 (accessed 28.06.19).

[5] A. Daly, P. Zannetti, Chapter 2, Air Pollution Modeling – An Overview, in: P. Zannetti, D. Al-Ajmi, S. Al-Rashied (Eds), Ambient Air Pollution, Publishing The Arab School for Science and Technology (ASST) and The EnviroComp Institute, (2019) pp.15-28. http://home.iitk.ac.in/~anubha/Modeling.pdf, 2019 (accessed 28.06.19).

[6] M.E Berlyand. Current Problems of Atmospheric Diffusion and Pollution. Gidrometeoizdat, Leningrad, 1975 (in Russian).

[7] Methods of Calculating Pollutant Concentrations in Atmospheric Air as Present in Factory Discharges. OND-86.1987. Gidrometeoizdat, Leningrad, 1987. https://files.stroyinf.ru/Data1/2/2826/index.htm, 2019 (accessed 28.06.19).

[8] L.N. Gutman, Introduction to the Nonlinear Theory of Mesoscale Meteorological Processes, Gidrometeoizdat, Leningrad, 1969 (in Russian).

[9] G. I. Marchuk, Mathematical modelling in the environmental problem, Gidrometeoizdat, Leningrad, 1982 (in Russian).

[10] F.G. Shuman, L.R. Hovermale, An Operational Six-layer Primitive Equation Model. J. Appl. Mech. 7 (1968) 525-547.

[11] M.E. Berlyand, Forecast and Regulation of Atmosphere Pollution, Gidrometeoizdat, Leningrad, 1985 (in Russian).

[12] https://www.google.ge/search?q=загрязнение+атмосферы,2019 (accessed 28.06.19).

[13] L. Gverdtsiteli, Atmospheric air protection technique, Publishing house “Technical University”, 2017 (in Georgian).

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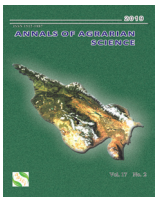

Impact of uncontrolled landfills on ecosystems of Georgia

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A B S T R A C T

Impact of the most noticeable uncontrolled landfills in some regions of East and West Georgia on the pollution degree of adjacent territories is studied. Frequently, it is not manageable to move West from the given territories or take them away and, as a consequence, pollutants remain there for many years and become one of the sources of contamination of adjacent territories by different types of waste. As a result, the sanitary state of these territories significantly worsens. Considering this problem, hydrochemical and microbiological analyses of samples (soil and water) were conducted and key pollutants that cause environment contamination through landfills were identified. All kinds of laboratory analysis were carried out in the accredited Laboratory of the Department of Environmental Pollution Monitoring at the National Environmental Agency, while in the field the physical and chemical indicators (in case if uncontrolled landfills usually being situated on the riverside) of water were measured using portable devices (Hydrometeorological Institute). The degree of the impact of uncontrolled landfills on ecosystems was assessed along with those negative processes, which may develop among population residing in the given region.

Keywords: Uncontrolled landfill, Pollution, Hazardous waste, Biogenic properties, Microbiological properties, Ecosistem.

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Introduction

As a matter of fact, there are a lot of uncontrolled landfills in Georgia. They are mostly located in the gorges near rivers, pastures and in the vicinity of settlements. Concequently, it is urgent to know the negative impact they produce on surrounding territories and how dangerous they might be for human health. Harmful substances can most probably be found in landfills of this type since there are yet no specific landfills for hazardous waste in our country. At the same time, mercury thermometers, lamps, batteries of different types, equipment and devices of all sorts containing different types of hazardous substances are imported in our country and in case of their fall into disuse they most probably are found in uncontrolled landfills. At the same time local authorities in Georgia, especially in regions, are still unable to provide the population with special equipment for garbage collection and relevant serviceis, due to which the number of uncontrolled landfills on the given territory increases [1].

Objectives and methods

Under laboratory conditions, using up-to-date methods and equipment (ISO methods) the polluting ingredients which frequently cause pollution of ecosystems as a result of direct impact of this type of landfills [2-9] were identified in the samples. Therefore, we took samples (water, soil – 0-20 cm) in the field and some basic ions (HCO_3^-, CI^-, SO_4^{2-}), some forms of biogenic elements (NO_2^-, NO_3^-, NH_4^+, PO_4^{3-}) and heavy metals (Cu, Zn, Pb, Cd, As, Hg) were measured in them. From the viewpoint of assessment of sanitary state of territories adjacent to landfills, microbiological indicators (indicator microorganisms), such as total Coliforms, fecal strep-

tococci, and E-coli were also measured. Physical and chemical indicators (pH, temperature, electric conductivity, water dissolved oxygen, salinity) were measured in the field (if the landfill was situated on the riverside) using a mobile device. Thus, objects of our research were studied fully – from hydro-chemical and physical and chemical as well as from the microbiological standpoint [10-15].

In order to properly evaluate the role and significance of landfills in the process of pollution of surrounding territories objects of survey were selected to define the background pollution. They were compared with the results obtained from other points under the study. In order to make the obtained results more precise, the data were also compared with máximum permisible concentración (MPC) or Estimated Allowable concentrations (EAC) of the determined components [16-28].

Results and analysis

First expedition was organized in the Kakheti region. Respectively, samples were taken in Nukriani and Zemo Magaro villages and the city of Telavi (territory adjacent to the Railway Station).

Based on the obtained data, such cancerogenic components as Cd and Hg were not found in any sample. As to Cu, Zn and Pb, their concentrations in some samples exceeded corresponding maximum allowable or Estimated Allowable concentrations. For instance, in Nukriani village copper concentration in soil sample exceeded MPC nearly 3 times, zinc content exceeded 1,6 times. In Magaro village copper concentration in samples was almost 2,5 times higher than MPC, while lead in soil samples of Telavi turned out to be 1,7 times higher than MPC. It should be noted that the level of heavy metals in samples taken from territories adjacent to landfills exceeds corresponding level in samples taken from background, which indicates that uncontrolled landfills have some impact on pollution processes of adjacent territories (Figures 1-3).

Table 2 demonstrates the level of some heavy metals in soil samples of territories near uncontrolled landfills situated nearby Ksani river in Mukhrani village (Shida Kartli), while Tables 3-4 show the results of hydro-chemical and microbiological analyses.

In the given case, lead concentration in the soil samples taken from adjacent territory exceeded the corresponding MPC 4,2 times, zinc concentration – 1,7-times, while copper concentration – twice (Table 2). So, the territory adjacent to the given landfill is also polluted by heavy metals and, therefore, their concentrations exceed the ones of background samples (cadmium and mercury were not found in the samples).

Samples of Ksani river were taken in the vicinity of the landfill and on the spot located 500 meters away from it (as a background). Obtained results are given in Tables 3, 4. It turned out that concentration of only one component, ammonia ions (NH_4^+) was found above permissible limit (2 MPC in sample taken from territory adjacent to the landfill), that means small impact of the landfill on river water quality, while microbiological pollution in the given testing point of Ksani river was not registered.

In Samtskhe-Javakheti region samples were taken in Aspindza village (territory adjacent to the landfill) and in the city of Akhaltsikhe (territory adjacent to Potskhovi river).

High concentration of lead was registered in samples of Aspindza and Akhaltsikhe equalling to 3,5 and 5 MPC, respectively. It should be noted that the concentration of lead in both cases are higher than that of background points (see Figures 4-5).

During the inventory of uncontrolled landfills in Imereti region we singled out uncontrolled landfills of Chognari and Kukhi villages, where samples (soil, water) were taken from their surrounding territories. According to the obtained results, lead concentration in soil samples taken from territories adjacent to Chognari landfills exceeded MPC values 1,8 times, while in Kukhi village reached 1,5 MPC. Slightly increased concentrations were registered in case of lead (Figures 6-7).

As to Gubistskali river (Kukhi village), the results of its chemical, microbiological, physical and chemical analyses demonstrate that uncontrolled landfills located in its vicinity have no impact on water quality of this river.

Conclusion

According to the results of the conducted analyses, we can conclude that uncontrolled landfills studied by us have certain impact on their adjacent territories. Therefore, though small but still negative role of these landfills is noticeable in river pollution processes. Increased concentrations of such heavy metals as Pb, Cu, Zn were identified in soil samples, while presence of Cd and Hg was registered in none of the cases. Slightly increased level of ammonia ions are sometimes noticed in rivers. According to the results of microbiological analy-

ses, we can state that uncontrolled landfills located nearby the rivers have small impact on their ecological state.

It should be noted that on the territories of this type of landfills we frequently encountered cattle feeding in this anti-sanitary conditions with organic fractions of waste disposed on this territory. That may pose threat to the health of local population and cause very unfavorable results.

Acknowledgement

Above mentioned researche within a grant of Shota Rustaveli National Science Foundation (Grant № 217578) will be continued in other regions of Georgia.

Reference

[1] Cleanup Georgia, 2012, "Report on Municipal Solid Waste Management in Georgia".

[2] Z. Youcai, L. Jianggying, H. Renhua, G. Guowei, J. of Water, Air and Soil Pollution, Vol. 122 (2000) 281-297.

[3] D. Kumar, B.J. Alappat, ASCE Practice Periodicals of Hazardous, Radioactive and Toxic Wastes, Vol. 8(4), (2004) 253-264.

[4] J. Fronczyk, K. Garbulewski, Department of Geotechnical Engineering, Warsaw University of Life Sciences, Land Reclamation, Vol. 41, (2009) 3-9.

[5] G.S. Fomin. Soil: Control of quality and ecological safety according to international standards. Reference book. "VNIIstandart", M., 2000 (in Russian). [6] F.B. Calvo Moreno, M/ Zamorano, M. Szanto, Environmental diagnosis methodology for municipal waste landfills. Waste Manage 2005;25:768–79.

[7] AS. Erses, MA Fazal, Onaya TT, Craig WH. Determination of solid waste sorption capacity for selected heavy metals in landfills. J Hazard Mater 2005;B121:223–32.

[8] AD. Eaton, Franson MAH, American Water Works Association, Water Environment Federation. Standard method for the examination of water and wastewater. 21st ed. Washington: American Public Health Association; 2005.

[9] G.S. Fomin. Waterr: Control of chemical, bacterial and radiation safety according to international standards. Encyclopedic reference book, «Protector», M., 2010 (in Russian).

[10] D. Kumar, B.J. Alappat, In: Proceedings of the Ninth International Landfill Symposium, Cagliari, Italy, (2003) no.400.

[11] APHA, 21st edition, American Public Health Association, Water Environment Federation Publication, Washington, DC., 2005.

[12] Milios, Leonidas, Christian Fisher, Andrea Rispo, "How Existing Municipal Solid Waste Data in ENPI East Countries Can Be Used for the Development of Waste Indicators", 2014.

[13] A.A. Halim, H.A. Aziz, M.A. Johari, K.S. Ariffin, M.N. Adlan, Journal of Hazardous Materials, Vol. 175 (1-3), (2010) 960-964.

[14] R. Nagendran, A. Selvam, K. Joseph, C. Chiemchaisri, a brief review. Waste Manage 2006;26:1357–69.

[15] T. Narayana, from waste disposal to recovery of resources. Waste Manage 2009;29:1163–6.

[16] Methodical guidelines for measuring the quality of contamination of soil with chemical substances Mm 2.1.7. 004-03 Adopted by the Ministry of labor Health and Social Affairs 2003 year 24 fabruary N 38/N.

[17] Gambashidze G.O., Blum W.H., Urushadze T.F., Mentler A., Heavy metals in soils, J. Annals of Agrarian Science, vol.4,№3 (2006) 7-11.

[18] Gambashidze G.O., Urushadze T.F ., Blum W.H., Mentler A., Heavy metals in some soils of the West Georgia, Pocvavedenie, 8 (2014) 1014-1024.

[19] Supatashvili G.D.,Labartkava N.A.,Loria N.V., Dugashvili D.T. Arsenic in soil and plants food products of mining and processing region of Arsenic sulfide ore in Georgia. J. Annals of Agrarian Science, vol.8,№4 (2010) 31-34.

[20] Urushadze T.F ., Gambashidze G.O., Blum W.H., Mentler A. Soil contamination with heavy metals in imereti region (Georgia), Bulletin of the National Academy of Sciences, 175 (2007) 122-130.

[21] Felix-Henningsen P., Sayed M., Narimanidze E.L., SteffensD., Urushadze T.F. Bound forms and plant availability of heavy metals in irrigated , higly polluted kastanozems in the Mashavera valley, SE Georgia Annals of Agrarian Science Vol.9,№1,2011.

[22] Felix-Henningsen P., Urushadze T.F., Narimanidze E.L., Wichmann L., SteffensD., Kalandadze B. Heavy metal Pollution of soils Food crops due to mining wastes in the Mashavera river valley. Bull.Georgian National Academy Sciences, vol.175,№3, (2007), 97-106.

[23] Loria N., Labartkava N., Dugashvili D. The content of Arsenic and Cooper in Environmen-

tal objects of river Poladauri Gorge, Georgian chemical J., vol.4, №2, 2009, 177-179
[24] European Soil Data Base version 1.0. CD-ROM, European Soil Bureau, JRC, European Commission, 1999.
[25] Environmental Policy and Regulation in RUSSIA – (Organization for economic cooperation and development) OECD – http://WWW.oecd.org/env/outreach/38118149.pdf
[26] Vodyanicky Yu.N. Soil pollution by heavy metals and metalloids and their threat (analytical review), Soil Science, 7 (2013), 872-881 (in Russian).
[27] Vodyanicky Yu.N. Soil pollution by metals and metalloids. MSU, Moscow, 2017, 193 (in Russian).

Table 1. *The heavy metal concentration in the soil samples collected from the surrounding areas of the uncontrolled landfill sites in Kakheti Region*

Sampling location	Pb	Cd	Zn	Cu	Hg
	mg/kg				
Vil. Gombori (background)	22,26	N.D.	170,00	120.30	N.D.
Vil.Nukriani (Sighnaghi Region)	35.65	N.D.	359,38	384.35	N.D.
Vil. Zemo Magharo (Sighnaghi Region)	25,34	N.D.	233,41	324,47	N.D.
Telavi City (near the railway station)	52.86	N.D.	327,69	270,47	N.D.
MPC (mg/kg)	32	2			
EAC (mg/kg)			220	132	

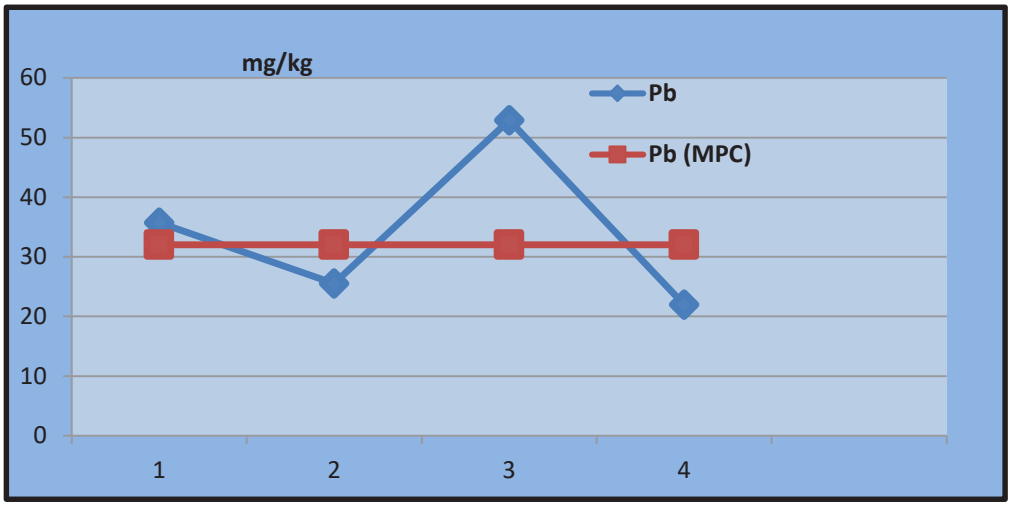

Fig. 1. *The Lead concentration in the soil samples collected in Kakheti Region*

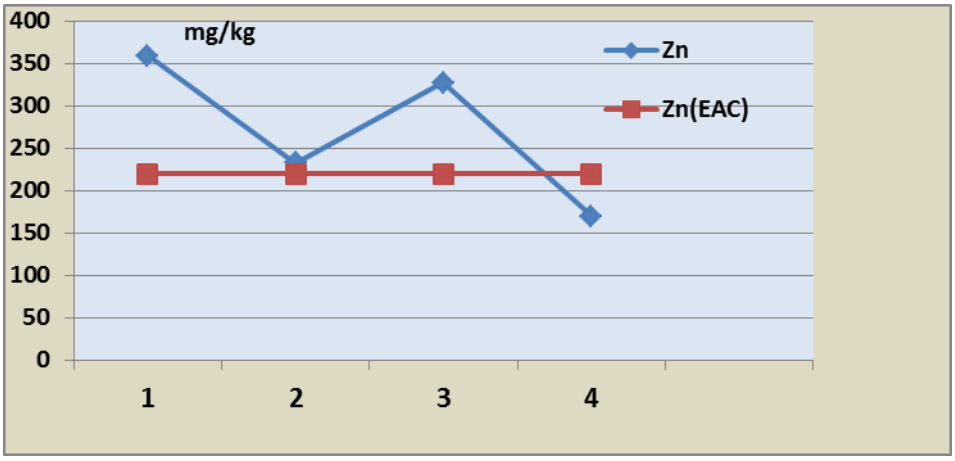

Fig. 2. *The Zinc concentration in the soil samples collected in Kakheti Region*

1 - vil. Nukriani
2 - vil. Zemo Magharo
3 - Telavi city
4 - background

Zn - concentration
Zn - EAC

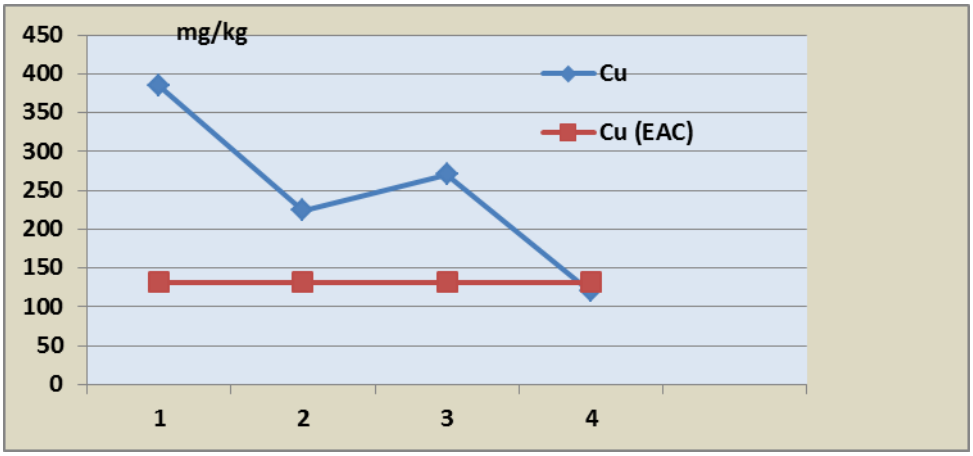

Fig. 3. *The copper concentration in the soil samples collected in Kakheti Region*

1 - vil.Nukriani
2 - vil. Zemo magharo
3 - Telavi city
4 - background

Cu - concentration
Cu - EAC

Table 2. *The heavy metal concentration in the soil samples collected from the surrounding areas of the uncontrolled landfill sites in Shida Kartli Region*

Sampling location	Pb	Cd	Zn	Cu	Hg
	mg/kg				
Vil. Mukhrani	137,66	N.D.	375,88	256.31	N.D.
MPC (mg/kg)	32	2			
EAC (mg/kg)			220	132	

Table 3. *The results of hydrochemical and microbiological analysis of Ksani river (Near landfill, Mukhrani)*

№	Ingredients	Unit	Results	MPC	Methods
1	NH_4^+	mgN/L	0,685	0,39	ISO 7150-1:2010
2	NO_2^-	mgN/L	0,015	1.0	ISO 10304-1:2007
3	NO_3^-	mgN/L	0,177	10.0	
4	PO_4^{3-}	mg/L	0,035	3.5	
5	SO_4^{2-}	mg/L	9,199	500	
6	CI^-	mg/L	1,107	350	
7	Br^-	mg/L	0,108	0.2	
8	F^-	mg/L	0,003		
9	E-coli	Unit per liter	450	5000	Membrane-filtration
10	Total Coliforms	Unit per liter	1300		
11	Feacal Streptococci	Unit per liter	450		

Table 4. *The results of hydrochemical and microbiological analysis of Ksani river (500m. from the landfill, Mukhrani)*

№	Ingredients	Unit	Results	MPC (mg/l)	Methods
1	NH_4^+	mgN/L	0,352	0,39	ISO 7150-1:2010
2	NO_2^-	mgN/L	0,061	1.0	ISO 10304-1:2007
3	NO_3^-	mgN/L	3,781	10.0	
4	PO_4^{3-}	mg/L	0,436	3.5	
5	SO_4^{2-}	mg/L	17,044	500	
6	CI^-	mg/L	7,316	350	
7	Br^-	mg/L	0,081	0.2	
8	F^-	mg/L	0,103		
9	E-coli	Unit per liter	--	5000	Membrane-filtration
10	Total Coliforms	Unit per liter	600		
11	Feacal Streptococci	Unit per liter	--		

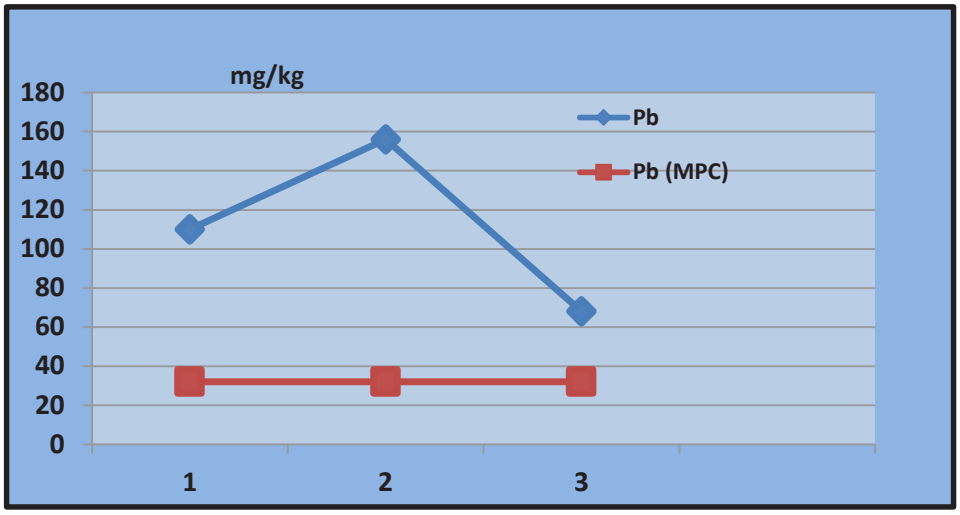

Fig. 4. *The Lead concentration in the soil samples collected in Samtskhe-Javakheti Region*

1 - Aspindza
2 - Akhaltsikhe
3 - background

Pb - concentration
Pb - MPC

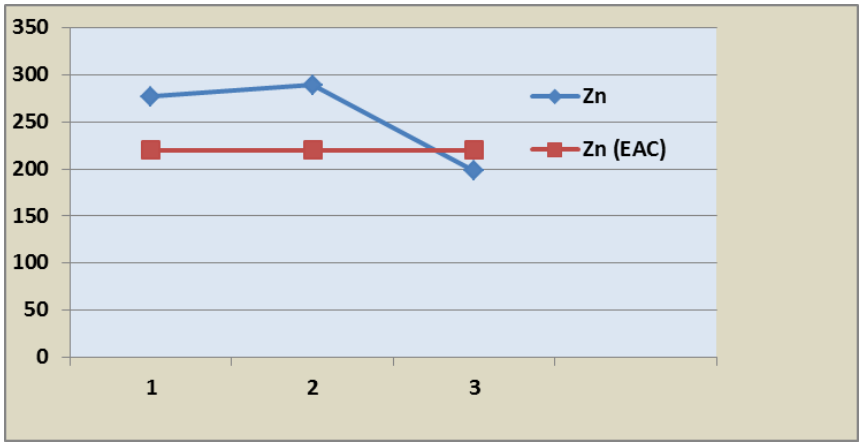

Fig. 5. *The Zinc concentration in the soil samples collected in Samtskhe-Javakheti Region*

1 - Aspindza
2 - Akhaltsikhe
3 - background

Zn - concentration
Zn - EAC

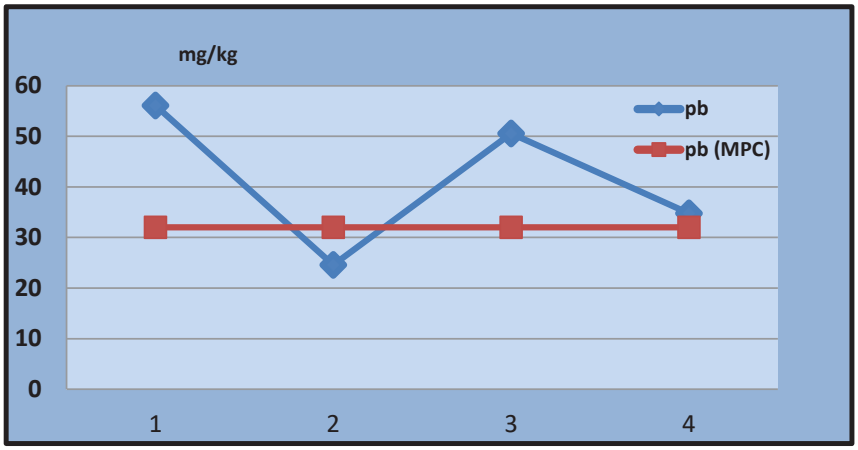

Fig. 6. *The Lead concentration in the soil samples collected in Imereti Region*

1 - vil. Chognari
2 - vil. Chognari (background)
3 - vil. Kukhi
4 - vil. Kukhi (background)

Pb - concentration
Pb - MPC

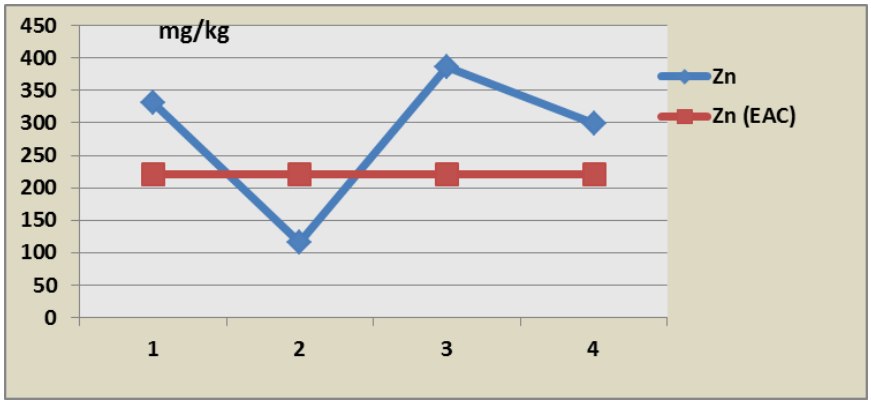

Fig. 7. *The Zinc concentration in the soil samples collected in Imereti Region*

1 - vil. Chognari
2 - vil. Chognari (background
3 - vil. Kukhi
4 - vil. Kukhi (background)

Zn - concentration
Zn - EAC

Table 5. *The results of hydrochemical and microbiological analysis of Gubistskali river (Near landfill)*

№	Ingredients	Unit	Results	MPC (mg/l)	Methods
1	NH_4^+	mgN/L	0,554	0,39	ISO7150-1:2010
2	NO_2^-	mgN/L	0.122	1.0	ISO 10304-1:2007
3	NO_3^-	mgN/L	0.727	10.0	ISO 10304-1:2007
4	PO_4^{3-}	mg/L	0.192	3.5	ISO 10304-1:2007
5	SO_4^{2-}	mg/L	48.25	500	ISO 10304-1:2007
6	CI^-	mg/L	4.79	350	ISO 10304-1:2007
7	Br^-	mg/L	0,082	0.2	ISO 10304-1:2007
8	F^-	mg/L	0.115		ISO 10304-1:2007
9	E-coli	Unit per liter	3500	5000	Membrane-filtration
10	Total coliforms	Unit per liter	8200		Membrane-filtration
11	Feacal Streptococci	Unit per liter	550		Membrane-filtration

Table 6. *The results of hydrochemical and microbiological analysis of Gubistskali river (300m. from the the landfill)*

№	Ingredients	Unit	Results	MPC (mg/l)	Methods
1	NH_4^+	mgN/L	0,354	0,39	ISO7150-1:2010
2	NO_2^-	mgN/L	0.112	1.0	ISO 10304-1:2007
3	NO_3^-	mgN/L	0.527	10.0	ISO 10304-1:2007
4	PO_4^{3-}	mg/L	0.162	3.5	ISO 10304-1:2007
5	SO_4^{2-}	mg/L	47.22	500	ISO 10304-1:2007
6	CI^-	mg/L	4.99	350	ISO 10304-1:2007
7	Br^-	mg/L	0,098	0.2	ISO 10304-1:2007
8	F^-	mg/L	0.101		ISO 10304-1:2007
9	E-coli	Unit per liter	2400	5000	Membrane-filtration
10	Total coliforms	Unit per liter	7400		Membrane-filtration
11	Feacal streftococci	Unit per liter	380		Membran-filtration

Table 4. *Physico - Chemical properties of Gubistskali river*

Sampling location	pH	Conductivity, msm/cm	salinity, (%)	Dissolved oxygen, mg/L	t^0c
Gubistskali river (near landfill)	7.9	224	0.1	7.8	13.8
Gubistskali river (500m. from the landfill)	7.95	210	0.1	7.6	13.6

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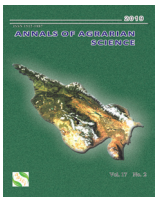

Use of plant raw materials for purification of industrial waste waters from copper and iron ions

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A B S T R A C T

The purification of quarry waters of the mining enterprise "RMG Copper" (Bolnisi district, Georgia) and Kazretula River from copper and iron ions through the adsorption method is investigated. Plant raw materials (agricultural waste), such as oak bark, corn cobs, grape stalks and damp pine cones etc., have been used as adsorbents. Dependence between the plant raw material adsorption degree and contact time, environment PH of a tested solution, preliminary treatment of the adsorbent is studied. In case of quarry water the best results were shown by the following adsorbents: oak bark, pine cones, corn cobs, the adsorption degree of which comprised: for copper 54,5; 43,0; 38,9%, respectively, while for iron the mentioned figures are as follows: corn cobs – 70%; pine cones – 56,6%; Plane tree leaves – 62,9, and oak bark – 60%. The similar tests have been conducted during Kazretula River purifying. The oak bark, corn cobs, damp pine cones turned out to be the relatively best adsorbents in the mentioned tests: a purification degree from copper was 60; 56; 48%, while from iron – 73,2; 59,8; 64%, respectively. We suppose that the abovementioned agricultural waste can be recommended as adsorbents in geochemical (sorption) barriers approved in the world practice, which represent the complex of protective measures and constructions creating obstacles on the way of heavy metal ions migration.

Keywords: Adsorption, Volume capacity, Quarry water, Plant raw materials, Waste water. Cooper

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Introduction

The technologies of extraction and processing existing today in mining, chemical and metallurgical industries are the powerful sources of negative, anthropological influence on the environment. This influence is manifested in the form of pollution of atmospheric air, surface and underground waters, soils and food products.

Mining industry is one of the branches, which has serious impact on environmental pollution by heavy metal ions (HMI) having high toxicity.

It was established through scientific investigations that systematic penetration of heavy metals into human body is especially hazardous for health, since they are characterized by biological peculiarities, such as: accumulation ability in the organism, mutagenic, carcinogenic, embryotoxic properties. Heavy metals' toxic effect is of a special nature in case of children and pregnant women.

The copper accumulation in large quantities in human body causes the Wilson's disease that implies excessive copper accumulation in the brain tissues, skin, liver, pancreatic gland, eyes, and kidneys. It damages the liver and nervous system and frequently becomes the reason of a lethal outcome [1].

The excessive iron content also has the negative impact on human body, it sometimes causes coma and even the death.

According to foregoing, the study and elaboration of simple processing methods of purification of waste (quarry) waters of industrial enterprises from HMI is of undoubted interest.

Local enterprise "RMG Copper" (copper-processing combine) of Bolnisi District (Georgia) faces this problem, too.

Kazretula River flows under the quarry tailing dumps and is rich in ore elements (Cu, Zn, Fe, Cd

etc.). The total content of heavy metals in Kazretula River considerably exceeds the allowable concentrations for surface waters. It should be noted that water of the mentioned river is used for irrigation of agricultural lands in Bolnisi district and creates a threat of agriculture production pollution with heavy metals and causes various severe illnesses.

There are known many traditional, up-to-date and non-traditional methods of waste waters (mine, quarry and underspoil waters) treatment, for instance: chemical, membranous, ion exchange, galvanogenic, electrochemical, sorption, extraction methods and so on. However, most of these methods have number of lacks, such as origination of the secondary pollution, necessity of the special complex devices and structures that makes the production nonprofitable [2, 3].

Taking into account the generalization of literature data, carried out explorary researches and RMG Copper's technological scheme we suppose that the role of geochemical barrier technologies, i.e. complex of protective measures and structures installed on the migration way of different toxicants, including HMI, increasingly grows in the solution of mentioned problem. A geochemical barrier is the area, on which in a short time a sharp fall of migration and concentration of chemical elements takes place. The essence of this method lies in the transition of polluting components into a less moving form. Geochemical barriers play "filtering function" kind of role. Significant part in these technologies is assigned to sorption barriers made of different sorbents [4, 5].

There are developed and investigated the sorbents on the basis of a wide variety of mineral and organo-mineral raw materials, synthesized polymers, industrial and agricultural waste.

In recent years in order to remove the heavy metal ions dissolved in the water the successful use of the sorption materials on the basis of vegetable waste has been started, namely: coconut and cedar nut shells, rice husk, buckwheat, wood chips, straw and many other wastes [6-11]. The vegetable waste, such as sunflower, oat, buckwheat, rice husks contains cellulose (up to 30%) and lignin (up to 25%) in their chemical composition, i.e. substances, which are able to carry out the processes of physical sorption and chemosorption [12].

Sunflower husk is the easily-accessible large-tonnage waste at the relatively small price, that's why it is considered as a prospective raw material for production of sorption materials [13-15].

The different groups of chemical substances: lignin, polysaccharides, alkanes and long chain of alcohols have been detected in the grape stalks and pine bark [16-20].

It is also known that the oak bark is rich in tanning substances: catechin, gallotanin, quercetin, free gallic acid that are able to form insoluble complex compounds with heavy metal ions [21-23].

The use of these materials can reduce the expenses for waste water purification several times. The important economic factor is that the vegetable waste of agricultural enterprises serves as a raw material used for such prospective adsorbents. At the same time, it gives us an opportunity to relate the problem of their disposal with the improvement of ecological state of water resources.

In the previous works related to the process of quarry waters purification from heavy metal ions we have studied natural, local alumosilicates, both clays (gumbrin, Askangel) and zeolites (clinoptilolite, mordenite) and also mineral brucite. There was shown that the above mentioned alumosilicates have sorption activity towards HMI [24, 25].

Materials and methods

In the given work there is studied purification of industrial waste quarry waters and Kazretula river waters from copper Cu^{2+} and iron Fe^{+2} ions by adsorption method [26].Vegetable raw materials were used as adsorbents: oak bark, grape stalks, sunflower pellets, corn cob, spruce sawdust, walnut partition, plane tree leaus and pine cones.

Experimental part

Study of sorption properties of mentioned sorbents was conducted under optimum conditions.

The water samples of the river Kazretula were taken at a 2000 meters away from the quarry, and quarry water samples from the water reservoir, from which the quarry waters go for processing. Samples were taken in accordance with technical regalement of "sanitary rules of taking water samples" of Ministry of Infernally Displaced Persons from the Occupied Territories, Labour, Health and Social Affairs of Georgia N15/N (Law article 15 and 23)[27].Samples were several times washed by distilled water for removal of dust and other admixtures and afterwards were dried at room temperature and grinded. 5 g weights of abovementioned sorption materials were placed into test flask with a capacity of 250 cm^3, then 50 cm^3 of surveyed solution

were added and a mixture stirred during an hour in the magnetic stirrer CSM305 at the 800 rpm rate, afterwards the adsorbent was removed via filtration, and copper and iron ions concentrations have been determined in the filtrate.

Analyses have been conducted by atomic-adsorption (AAC), Perkin-Elmer (Analyst-200), photometric (KFK-2) and chemical methods. Each trial of we proceed 3-times, we take the average and the results are given in table and drawings.Metal ions quantity absorbed per 1 g of sorbent (volume capacity) – A (mg/g) and adsorption (purification) degree of solution R% were calculated by formulas

$$A = \frac{C_o - C}{m} V \text{ mg/g}$$

$$R = \frac{C_o - C}{C_o} \cdot 100\%$$

where C_o – initial concentration, mg/dm^3;
C – concentration after test;
m – sorbent mass, g;
V – volume of purified solution, dm^3.**[26].**

Results and discussion

Regularities of quarry and river (Kazretula) waters purification from copper and iron ions by adsorption methods are researched [26]. The studied quarry water belongs to waters of average mineralization, composition of which is changed depending on seasons. Copper and iron concentration in quarry water studied by us was varied within ranges of 201,6-560,1 mg/l and 462-560 mg/l,, while in Kazretula River 2,5 mg/l and 11,2 mg/l, respectively.

The impact of plant raw materials adsorption degree on contact time, environment pH, preliminary processing of adsorbent in relation to heavy metals sorption is studied.

The dependence of adsorption degree and volume capacity from the species of plant raw materials (adsorbents) is shown in Tables 1 and 2.

Table 1. *Dependence of copper and iron ions adsorption on the adsorbent (Quarry water ,pH = 3, τ = 1 h)*

№	Adsorbent	R, %		A, mg/g	
		Cu(2+)	Fe_{total}	Cu(2+)	Fe_{total}
1	Oak bark	54,5	60,0	3,05	2,77
2	Grape stalks battered	12,5	34,5	0,70	1,58
3	Grape stalks unbattered	30,4	40,9	1,70	1,84
4	Sunflower pellets	12,6	59,0	0,70	2,65
5	Corn cobs	38,9	70,0	2,20	3,15
6	Spruce sawdust	2,2	53,5	0,12	2,47
7	Walnut partitions	14,0	16,0	0,78	0,74
8	Plane tree leaves	8,23	62,9	0,05	2,89
9	Damp pine cones	43,0	56,6	2,41	2,55
10	Damp pine cones treated with 1N NaOH	51,0	68,0	2,85	3,06

Research results of dependence of adsorption degree on contact time for sawdust, oak bark and damp pine cones in relation to copper and iron are shown in Fig. 1.

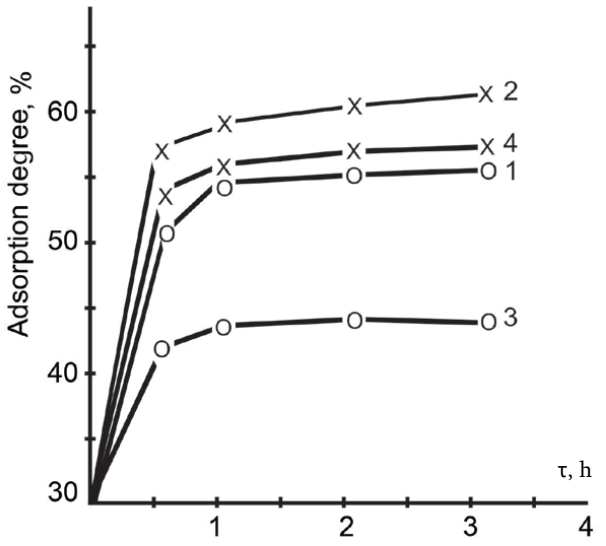

Fig. 1. *Contact time influence on adsorption degree for Cu2+ and Fe2+(pH = 3,0, ratio of adsorbent : solution volume – 1:10); 1, 2 – oak bark, 3, 4 – pine cones. o - Cu2+ x – Fe2+*

As is seen from diagrams, quarry water purification runs effectively after 30 minute contact and the maximum value of adsorption degree is reached within an hour, and afterwards isotherms negligibly go up and weak dependence between them is observed.

The maximum value of Cu^{2+} and Fe^{2+} ions adsorption degree is reached in case of oak bark and is 55 and 60%, respectively, in comparison with damp pine cones, for which it equals to 43 and 57%, respectively, when pH = 3.

According to some authors, the bark of some southern species of wood contains moderate quantity of tannins. It is shown that when purifying model solutions with the use of oak bark the metal ions enter into reaction with tannin-containing substances and form insoluble complex compounds with them [23]. It is probably one of the reasons of relatively high values of purification degree by oak bark compared with other adsorbents (see Table 1).

It is known that adsorption degree of sorbent is substantially depended on environment (solution) pH [18, 28], and due to this reason there was studied an impact of environment acidity on adsorption of sorbing materials – oak bark and damp pine cones. Adsorption isotherms in relation to Cu^{2+} and Fe^{2+} on mentioned sorbents are given in Fig. 2.

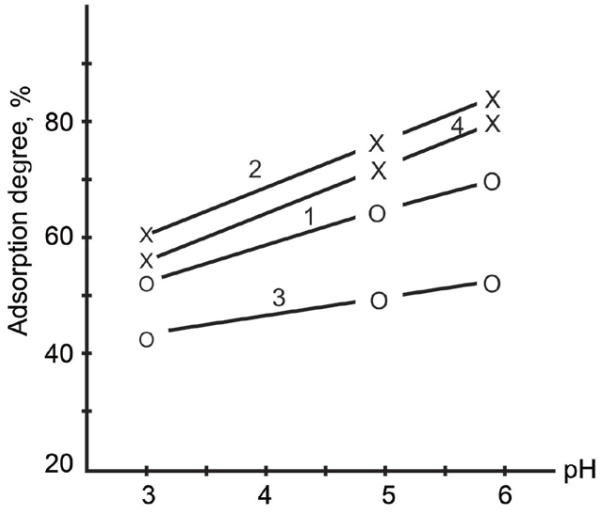

Fig. 2.*Impact of environment pH on adsorption degree of Cu2+ and Fe2+(τ = 1 hour, ratio of adsorbent : solution volume – 1:10); 1, 2 – oak bark, 3, 4 – pine cones. o - Cu2+ x – Fe2+*

As is seen from the diagrams, adsorption isotherms for copper and iron on both sorbents are almost of the same nature; they gradually go up. It is shown that maximum adsorption degree in relation to Cu^{2+} and Fe^{2+} ions in neutral environment (pH = 6) is observed in case of oak bark and is equal to 70 and 85%, while in case of pine cones it equals to 53 and 80%, respectively. Sorption degree on both sorbents in neutral environment is slightly higher than in acid medium, regarding both copper and iron.

It is established that this nature of sorption degree dependence on environment pH is related with change in state of active centers of sorbents. In case of low values of pH hydrogen ions totally dominate, and takes place promotion of sorbent surface that assists electrostatic repulsion of metal ions and reduction of their adsorption. At higher values of pH active centers of tannin-containing compounds (oak bark, grape stalks, pine cones) undergo dissociation and form corresponding phenolate anions, which are able to bind with metals ions and form chelate complexes [29].

In order to compare the effect of preliminary alkali treatment on adsorption degree, the adsorbent (pine cones) was preliminary treated with 1N NaOH solution. It was shown that after alkali treatment adsorption degree in relation to Cu^{2+} and Fe^{2+} increases by 8 and 12%, respectively.

Experimental data show that adsorption degree for all enumerated adsorbents regarding iron is higher than in relation to copper. Probably this is because of radius size of adsorbed cations, which plays important role. According to authors data copper cation radius is bigger than of iron cation and they equal to 73 r/P_m and 70 r/P_m, respectively [30].

Similar works have been carried out for the water of Kazretula River. Test results showed us that the oak barks (Cu – 60%, Fe – 73%), damp pine cones (Cu –48% and Fe – 64%) and corn cobs (Cu –56%, Fe – 60%) have purified the Kazretula water from heavy metals relatively well (Table 2).

Table 2. *Dependence of copper and iron adsorption on adsorbents (Riv.Kazretula,PH=5, τ = 1 h)*

Adsorbent	R, %		A, mg/g	
	Cu(2+)	Fe(2+)	Cu(2+)	Fe(2+)
Oak bark	60	73,2	0,015	0,082
Grape stalks battered	40	55,3	0,010	0,062
Corn cobs	56	59,8	0,056	0,067
Pine cones	48	64,0	0,012	0,072

It is known that the efficiency of adsorption processes depends not only on sorbent properties and quantity, but also on chemical nature and concentration of adsorbed substance. The more is the substance concentration in polluted water, the more quantity is adsorbed per each gram of the sorbent (A, mg/g). This fact is clearly seen from Tables 1 and 2, in case of reduction of heavy metal ions quantity in sorbent phase in Kazretula River and quarry waters.

Conclusion

On the basis of foregoing materials, one can recommend the use of geochemical sorption barriers as of obstacles on the way of migration of different heavy metal ions, where the cheap natural raw materials, such as oak bark, grape stalks, pine cones, corn cobs, and sunflower husk can be used as adsorbents. When using the mentioned raw materials as adsorbents the copper adsorption degree in case of quarry water comprised 54,5% for oak bark, 30,4% for grape stalks, 43% for damp pine cones, and 38,9% for corn cobs; while the iron adsorption degree was 60,0; 40,9; 56,6 and 70%, respectively.

In case of Kazretula River purification with the same quantity of adsorbents, the copper adsorption degree was 60; 40;48; 56; while the iron adsorption degree was 73,2; 55,3; 64% and 59,8; respectively.

References

[1] Environmental chemistry. Translation from English under the editorship of J. O.M. Bokris. Khimia, M., 1982.

[2] Kim TY, Park SK, Cho SY, Kim HB., Sorption of heavy metals by brewery biomass. Korean J. Chem. Eng., 22 (2005) 91-98.

[3] Ahuwalia SS, Coyal D., Removal of heavy metals by waste tea leaves from aqueous solution. Eng. Lige Sci, 5 (2005) 158-162.

[4] Perelman A.I., Vorobiev A.E., Landscape and geochemical conditions of location of enterprises of mining industry. Bulletin of RAS, geographic series, 2 (1994) 50-61 (in Russian).

[5] Izotov A.A., Koverdyaev O.N., Vershinina O.O., Methods for reduction of drainage waters impact on the environment in mining regions. Mining journal, 10, (2006) 103-106 (in Russian).

[6] Sciban S., Klasnja M., Skrbic B., Adsorption of copper ions from water by modified agricultural by-products. Desalination, vol. 229, iss. 1-3 (2008) 170-140.

[7] Ong S., Seng C., and Lim P., Kinetics of adsorption of Cu (II) and Cd (II) from aqueous solution on rice husk and modified rice husk. Electronic J. Environmental Agric. Food. chem., 5, (2007) 1764-1774

[8] Escuderon G., Gabaldon C., Marzal P. and Vill I., Effect of Edta on divalent metal adsorption onto grape stalk and exhausted coffee wastes. J. Hazard. Mater., 152 (2008) 476-485.

[9] Fiol N., Villaes I. and Poch I., Removal of lead(II) and cadmium(II) from aqueous solution using grape stalk waste, J. of Hazard. Materials B 133 (2006) 203-211.

[10] Valld C., Azebalo I.A., Casas I., Martinez M., Miralles N. and Florido A., Modelling of the Ni(II) removal from aqueous solutions onto grape stalk wastes in fixed-bed column. J. Haz. Mat. 174 (20100144-150.

[11] Shukla S.S., Yu LJ., Dorris KL., Shukla A., Removal of nickel from aqueous solution by sawdust. J. of Hazardous Materials, 2015, 121(1-3) (2015) 243-246.

[12] Sciban M., Klasnja M., Skrbic B., Adsorption of copper ions from water by modified agricultural by-products. Desalination, vol. 229, iss. 1-3 (2008)170-180.

[13] Sivolobova N.O., Gracheva N.V., Zhashueva K.A., Sikorskaia A.V., Adsorption materials

on the basis of sunflower husk. Engineering bulletin of Don,, 1 (2017) 2-8 (in Russian).
[14] Asubiojo O.I., Ajelabi O.B. Removal of heavy metals from industrial waste water using natural adsorbents, J. Toxicological and Environmental chemistry, 2009, vol. 91, iss. 5 (2009) 883-890.
[15] Abdelfatah I., Sayed F.E., Almedolab A. Removal of Heavy Metals from Waste Water using Corn Cob. Sustation Case Study, 2016.
[16] Machado R., Santos C., Correla M.J.N., Carvalho J.R., Biosorption of copper by grape stalks and pine bark biomasses. The European J. of Mineral Processing and Environmental Protection, vol. 3, no. 1 (2003) 108-118.
[17] Florido A., Valderrama C., Azevalo I.A., Casa S.I., Martinez M., Miralles N., Application of two sites non-equilibrium sorption model for the removal of Co(II) onto grape stalk wastes a fixed-bed column. Chemical Engineering J., vol. 156, №2 (2010) 298-304.
[18] Willaescusa I., Fiol N., Martinez M., Removal of copper and nickel ions from aqueous solutions by grape stalks wastes. Water Res., 38 (2004) 992 – 1002.
[19] Farin N.V., Matos G.D. and Arruda M.A.Z. Grape bagasse as a potential bio-sorbent of metals in effluent treatments. Bioresour. Technol., 98 (2007) 1940-1946.
[20] Farin N.V., Matos G.D., Lehmann E. and Arruda M.A.Z., Grape bagasse as an alternative natural adsorbent of cadmium and lead for effluent treatment. J. Hazard. Mater., 154 (2008) 1007-1012.
[21] Love the Team. What diseases are treated with oak bark, useful properties of the bark of oak 2001.
[22] Fenglian Fu, Qi Wang., Removal of heavy metals ions from waste waters. Preview. J. of Environmental Management, 92 (2011) 407-418.
[23] Yusupova A.I., Treatment of Waste Waters Containing Heavy Metal Ions by the Sorbents and Extracts from Tannin-Containing waste. The thesis work, Kazan, 2015 (in Russian).
[24] Kalabegashvili N.G., Ioseliani D.K., Balarjishvili G.I., Samkharadze L.O., Tsiskarishvili R.P., Dolidze A.V., Waste water purification from heavy metals with the use of local clays and mineral Brucite. Proceedings of the Georgian National Academy of Sciences, v. 43, №2, (2017) 162-164.
[25] Ioseliani D.K., Balarjishvili G.I., Kalabegashvili N.G., Samkharadze L.O., Mikadze I.I., Purification of waters polluted with heavy metals using adsorption method. World Science, 2018, №4 (32), vol. 1 (2018) 64-66.
[26] G.Tsitsishvili.Adsorbtio Process.Tbilisi,1959.
[27] The order N15/N "sanitary rulesofwater sampling " (Article 15 and 23) of Ministry of labor, health and social protection.22/01/2004, Tbilisi.
[28] Zhang Yu B., Shukva ASS Y., Dorris KL., The removal of heavy metal from aqueous solutions by sawdust adsorption-removal of copper. J. Hazard Mater. 80(1-3) (2000) 33-42.
[29] Shaikhiev I.G., Bagauva A.I., Removal of iron (III) ions by extracts of oak bark and leaves and study of morphology and kinetics of waste sedimentation. Water, chemistry and ecology, 3 (20140 70-84 (in Russian).
[30] Wells A.F., Structural inorganic chemistry, 5th ed., Clarendon Press, Oxford, 1984, p. 1288 (metallic radii for 12-coordination); Shannon R.D. Acta Crystallogr., Sect. A: Found. Crystallogr. 32, (1976) 751- 759.

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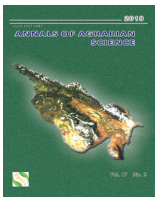

A local way of solonetz solonchak soils reclamation in Ararat valley by using factory wastes and natural minerals

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A B S T R A C T

The reclamation of solonetz-solonchak soils of Ararat valley has been performed by a local way. The required ameliorants as the hydrochloric acid (industrial waste) and the activated plaster (natural mineral) have been used only towards planting stocks rows, 2m x100m =200m^2, which makes 0.32 ha and in this case the amount of the required ameliorants is reduced for 3.1 times. Only the 600-800m^2 has been reclamated from one ha of land area. The expences for ameliorants purchase and transport have been reduced for 12-16 times. In current conditions it is suggested to reclamation the solonetz-solonchak soils by the local way, which will result in saving of financial resources.

Keywords: Solonetz-soloncak soils, Local reclamation, Industrial wastes, Hydrochloric acid, Natural minerals, Heat-treated plaster.

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Introduction

The development of agriculture, the usage of agricultural soils and the increase of their fertility have great importance for the land poor Republic of Armenia.

The cultivated soils area of the Republic makes 500 000 ha, and only 80. 000 ha of it is in kindly climatic conditions, that is, in Ararat valley. The main type of soils under cultivation in this area are the irrigated meadow-brown soils (53000 ha), which though make the 10 % of the Republic's cultivated soils, provide more than 40% of agriculture gross production.

There are about 25th.ha of solonetz solonchak soils of different degrees near the irrigated meadow-brown soils, which can be cultivated only by means of chemical reclamation [1].

Till the 1990s, 5400 ha of solonetz solonchak soils were cultivated by means of sulphuric acid and ferrous sulfate. The mentioned ameliorants were imported from the former Republics of the Soviet Union, but their import lasted till 1990.

Since independence of Republic of Armenia the drastic changes in the sphere of edaphic reserve management influenced both land conservation and their effective use.

Since 1990s, the meliorative-ecological balance of the soil-water-plant system was disrupted because of land privatization and other objective and subjective reasons. A significant amount of land plots was lost in the agricultural circulation, which was in result of the increase (50-150 sm) of the permissible level (300sm) of ground waters and the high level of hydrocarbonate-magnecial-sodium mineralization of that waters, etc. The ground waters level increase was due to the poor activity of horizontal and vertical underground drainage.

The year by year deterioration of soils reclamative state is also connected with the low level of land use in the Republic, with the utilization of waters having low irrigation factor, as well as with improper human treatment [2].

In result of the above mentioned negative factors, large areas of meliogenic and adjacent irrigated meadow-brown soils of the Ararat Valley have been exposed to secondary salinity-alkalinity and, consequently, there are for about 40th. ha of primary and secondary saline-salonized soils, which improvement depends on considerable financial expenses. In the given situation it is necessary to develop new systems for soils reclamation, which will be based

on local stuff or waste reserves base, and will have a crucial influence, both from economic and ecological point of view.

To the list of above mentioned ameliorants belong the 30% hydrochloric acid wastes of "Nairit" scientific production association, the industrial waste of finished cement dust, which contains 10% of free CaO and 40 % of fixed CaO, as well as land plaster, which solubility and the ameliorative effectiveness increases in result of heat treatment.

Objectives and methods

We reclimated the saline-alcaline soils of "Armavir" experimental-reclamative station in Armavir region and of the area of Zartonq community by means of local way of amelioration. For this purpose, hydrochloric acid of 30% and heat-treated plaster were used.

This method has been used only during the reclamation of the area under planting stocks, which makes an area of 1,5m x 1,5m=2,25m^2, and, in this case, only the 600-700m^2 area of hectare check plot is reclamated, that is, from 1/14 to 1/16 part of the required ameliorant is used, and consequently, the use of the financial resources is saved for 14-16 times.

In case of stocks planting system change, the ameliorative area may slightly change, and accordingly, the invested financial resources will differ.

In the one hectare check plot of Armavir region's Zartonq community the hydrochloric acid (30%) was used by rows, in beds with 2m width and 100m length. In the **200** m^2 reclamated area 16 fruit planting stocks should be planted, and then again, after each 5m hills were made with 2m width and 100m length towards the rows**.**

So, 16 check plots with 2m width and 100m length were made in a 1 hectare area. With this approach, we have planned to reclamate only the 3200m^2 × 10000m^2, which leads to the amount decrease of necessary ameliorant and hutch water for 3.1 times.

Before getting ameliorants land levelling was performed and soil samples were taken from 1 m depth. They were taken from 5 soil profiles of 0-25, 25-50, 50-75 և 75-100 sm depth.

Results and analysis

The soil mechanical composition, the chemical composition of water extract and the content of exchangeable sodium and potassium were studied by laboratory research, which allowed to calculate the amount of the necessary ameliorant of hydrochloric acid and heat-treated plaster for the reclamation of a hectare check plot and the norm of the hutch water.

The results of laboratory research, which are the average data of 5 soil profiles of 0-100m layer, are shown in Table 1.

Table 1. *The chemical composition of soil under study according to water extract and the amount of exchangeable Na and K in 0-100sm of soil layer*

Soil layer, sm	pH	Salts	Water-Soluble ions in meq/100g soil							Exchang.	
			CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na+K	Na	K
0-100	9,3	1,320	1,320	2,01	15,15	3,30	0,30	0,11	19,80	11,4	1,8

According to the mechanical composition the soil under study is heavy loam, and 1.35 coefficient is used for the calculation of required amount of the ameliorant. The required ameliorant amount has been calculated as follows:

1. HCl(30%)=3,65 t/ha ×1,35×3,33=16,4 t/ha, 1meq HCO_3+for the exchangeable sodium neutralization, in a meter layer (0-100sm) HCO_3 + exchangeable Na =13,41meq-3,0meq (permissible border in soil) = 10,4 ×16,4 t = 170,6 t/ha HCl(30%)
2. Heat treated plaster= 8,6 t/ha+1,35=11,6 t/ha 1meq) HCO3+ for the exchangeable Na sweetening, for 1ha it will make` 11,4 t/ha × 10,4 meq=120,6 t/ha

The required ameliorants amount data are shown in Table 2.

Table 2. *The amount of the required ameliorant and hutch water, by using local way of chemical reclamation*

Variant	In meq/100g soil			1meq HCO_3+ exchang. Na	For 1ha t/ha	For 2,25m^2, kg	Required hutch water, m^3	
	Total HCO_3	Exchang. Na	Total				hq/ա^3	2,25ա^2
HCl (30%)	2,01	11,40	13,41	10,4	170,6	38,4	47,85	10,8
Heat- treated plaster	2,01	11,40	13,4	11,6	120,6	27,14	47,85	10,8

In calculation process the 3 meq, which is the residual amount of HCO_3+ exchangeable Na in reclamated soils, is excluded from the 13,41 meq.

38.4 kg of HCl (30%) or 27.14 kg of heat-treated plaster is required for the occupied area of one nurcery plant (2.25 m^2).

The hydrochloric acid was also used for small check plots (2m×100m=200m^2), and for 1 ha it was given to 16 rows. The scheme of the stocks planting is as follows: the distance between rows is 6m and the planting stock distance is 6m. In this case, only the 3200m^2 of the hectare is reclimated and the amount of the required ameliorant is reduced for 3 times.

On the basis of the data, shown in Table 3, it is obvious that the soil 1 meter layer has been improved due to the used ameliorants, that is, HCl , heat-treated plaster and further leaching, the soil reaction has changed from strongly –alkaline to moderately alkaline, there is no CO_3^2 toxic ion in the soil, the Cl has been reduced from 15.15 meq to 0.31-0.62 meq/100g in soil, the water soluble Na-K is 1.81-1.88, and the exchangeable Na is in acceptable limits, that is, 2.60-2.80 meq/100g in soil.

Thus, the soil meter level has been improved and optimal conditions have been created for cultivated plant growth and development due to the chemical reclamation, made by a local way. It is necessary to apply irrigation-leaching regime in the process of agricultural reclamation (by increasing the irrigation amount for 30-40%), which will result in the decrease of water soluble Na amount, by reaching acceptable limits (<0,75 meq/100g in soil).

The change of the cation-exchange capacity during reclamation process is shown in Table 4.

The edaphic carbonates` $CaCO_3$, $MgCO_3$ have been decomposed by creating calcium and magnesium salts, which get into exchangeable reaction with the soil exchangeable sodium and push it out.

After reclamation the Ca amount prevails in soil, by reaching 52,8-54,0%, the Mg amount has slightly increased (3,0-3,9%), but the Na amount has changed from 39,3% to 10,1%.

During the last few years grain stillage is used as an industrial waste in the process of local way of reclamation [3, 4] and also ammonium sulfate is used, which is received in result of smoke gas extortion [5].

Thus, in current financial conditions it is possible to save the required expenses per one ha for 10-15 times by local way of melioration and to use the area for the gardens cultivation.

Table 3. *The chemical composition of reclamated saline-alkaline soil according to water extract and exchangeable Na and K*

Version	Soil layer, sm	pH	Salts, %	Water soluble ions, meq/100g							Exchang.	
				CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na+K	Na	K
Saline-Alk. soil	0-100	9,3	1,320	0,62	2,01	15,15	3,30	0,30	0,11	19,80	11,40	1,80
HCl (30%)	0-100	8,0	0,177	none	1,40	0,31	0,62	0,40	0,13	1,81	2,80	2,00
Heat treated plaster	0-100	8,1	0,203	none	1,26	0,62	0,91	0,60	0,16	1,88	2,90	1,80

Table 4. *The change of the cation-exchange capacity during local way of reclamation of solonetz-solonchak soils (0-100 cm in layer)*

Version	Soil layer, sm	pH	Salts, %	Water soluble ions, meq/100g							Exchang.	
				CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na+K	Na	K
Saline-Alk. soil	0-100	9,3	1,320	0,62	2,01	15,15	3,30	0,30	0,11	19,80	11,40	1,80
HCl (30%)	0-100	8,0	0,177	none	1,40	0,31	0,62	0,40	0,13	1,81	2,80	2,00
Heat treated plaster	0-100	8,1	0,203	none	1,26	0,62	0,91	0,60	0,16	1,88	2,90	1,80

References

[1] Papinyan V.A., Ways of Reclamation and Effective Usage of Solonetz-Solonchak soils in Ararat Valley (doctoral thesis), Yerevan, 2013.
[2] Manukyan R.R., Mamadjanyan S.A., Papinyan V.A., On the question of improvement of ecological-melioration state of hydromorphic irrigation meadow-brown soil of Ararat valley by usage of chemical materials, containing Ca, Bulletin of Armenian National Agrarian University - Yerevan, 3 (2007) 34-38 (in Armenian).
[3] Papinyan V.A., Ghazaryan U.K. The usage of grain stillage for the reclamation of solonetz-solonchak soils in Ararat valley, In: The ecology of regions (A source book lV of International scientific practical conference), Vladimir, Yerevan, 2012, pp. 62-71 (in Russian).
[4] Ghazaryan H.Gh., Papinyan V.A., Barseghyan M.H. The improvement of physical- chemical properties of the semi-desert soils by use of grain stillage, Agriscience, 3-4, March-April, 2013, pp 140-143 (in Armenian).
[5] Papinyan V.A., Manukyan R.R. The improvement of moderate saline sodic soils by use of ammonium sulfate. Bulletin of Armenian National Agrarian University-3, Yerevan (2016), 9-13.

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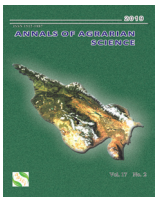

Synthesis and biological activity of 2,3,4,6-tetra-o-acetyl-1-O-(2-hloro-3-phenyl thio propyl)-β-D-Glucopyranose

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A B S T R A C T

Carbohydrate derivatives are distinguished with wide range of biological activity which is proven by successful usage of preparations made of Carbohydrate based in different branches of pharmaceutical chemistry. As a result of research of Carbohydrate compounde, the relationship between unique structure and its chemical and biological properties has been studied. Input of bulk liphophilic adamantane moiety in the proved medications or biologically active molecule in most cases is improved molecule's biological characteristic, drug's lipopilycity and prolonged actin is enhanced, and at the same time toxicity and side negative effects is reduced.We studied the reactions of acetylaryl glycosides with phenylsulfonyl chloride in the presence of a benzoyl peroxide catalyst. A new sulfur-containing glucoside was synthesized: 2,3,4,6-tetra-o-acetyl-1-O-(2-chloro-3-*phenyl thio propyl*)-β-D-Glucopyranose. The bactericidal properties of β-O-(2-chloro-3-*phenyl thio propyl*)-D-glucopyranose (4) of the obtained product after deacetylation were studied. With the help of the computer program PASS (Prediction of Activity Spectra for Substance) onlaines were able to predict the range of activity of substances. The obtained result established correlations on bactericidal properties between biological activity and the intended biological activity. The structure of the synthesized compounds was determined by physico-chemical research methods.

Keywords: Alliglycosides, Thioglycoside, Benzoyl peroxide, Phenylsulfonyl chloride, Bactericidal properties, Biological activity.

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Introduction

Thioglycosides are able to hydrolyze with acids to form mercaptans and the corresponding monosaccharides. However, these compounds are much more resistant to acid hydrolysis than their oxygen counterparts. They are easily broken down by specific enzymes. Thioglycosides have a sharp or burning taste and irritate the mucous membranes and skin, have a strong antimicrobial effect, in small doses stimulate appetite. Due to this property, some plants containing thioglycosides are used in medicine as local irritating and distracting agents for inflammatory processes and rheumatism.

Important compounds of carbohydrate origin are thioglycosides. Recent studies have shown that these compounds are characterized by very significant biological activity and are included in the composition of vitamins, enzymes and coenzymes. All organisms need sulfur [1-2], which it absorbs, in the form of any need. Sulfur-containing compounds are used as an antispasmodic effect, as well as an extension of the capillaries.

For the synthesis of sulfur-containing glucose, the reaction of the addition of monosaccharides (glucose) with phenylsulfonyl chloride was first studied.The starting compounds are synthesized by known methods. [3-4].

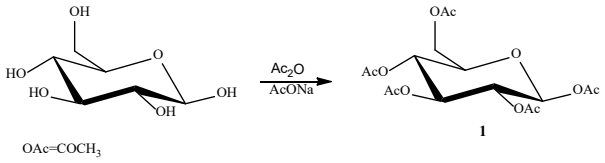
Experimental Part

With acetylation of glucose with acetic anhydride in the presence of sodium acetate on the obtained β-acetylated product (1) by the action of allyl alcohol and $BF_3[O(C_2H_5)_2]$ was syntheside 1-O-ally-2,3,4,6-tetra-o-acetyl-β-D-glucopyranose (2). A new compound 2,3,4,6-tetra-o-acetyl-1-O-(2-chloro-3-*phenyl thio propyl*)-β-D-Glucopyranose

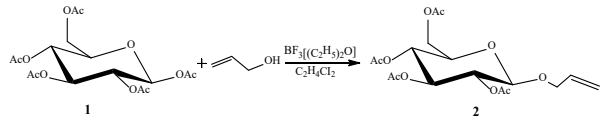
(3) was synthesized at room temperature in chloroform, in the nitrogen region, with mixing and adding phenylsulfonyl chloride solution (in CCI_4).

The synthesized compounds are white colored crystals, very soluble in chloroform. The composition of the derivative was determined by physico-chemical research methods.

In particular, the definition of optical rotation, using elemental analysis, IR and ^{13}C Spectroscopy. The purity of the substance was checked using thin-layer chromatography using "Silufol" plate in the following solvent system by volume: chloroform-ethanol 2:1. Optical rotation was measured on a SU-3 universal saccharimeter at 20^0 C. IR spectra of the samples were taken on a UR-20 spectrometer in KBr tablets. ^{13}C NMR was recorded on a Bruker AM-300, 75.5 MHz spectrometer in deuterochloroforme:



Allyl-2,3,4,6-tetra-O-acetyl-β-D-glucopyranose (2) was obtained in the interaction of penta-O-acetyl-β-D-glucose (1) with dichloroethane and with alilic alcohol with catalyst $BF_3[(C_2H_5)_2O]$:



By dissolving Allylated monosaccharides at room temperature in chloroform in the nitrogen region, in constant movements with the addition of a solution of phenylsulfonyl chloride (CCI4), a new compound was synthesized -2,3,4,6-tetra-o-acetyl-1-O-(2-chloro-3-*phenyl thio propyl*)-β-D-Glucopyranose (3) 51.8% with output, from which de-acetylations were obtained 1-O-(2-chloro-3-phenylethiopropyle)-β-D-Glucopyranose (4).

In the infrared spectrum of the synthesized products, the absorption band characteristic for the Allyl group is 1643-1700 cm^{-1}, and the following absorption bands are formed: 539, 596 cm^{-1} (C-S); 3070 cm^{-1} (C-H arom.); 690, 739 cm^{-1} (C-CI); 2824 cm^{-1} CH_2; 2850 cm^{-1} CH_3 (for the 3rd substance).

^{13}C NMR (δ, ppm,); $CDCI_3$; 19,38-30,084(RO-CO-$\underline{C}H_3$); 31,970-37,447(-CH_2); 77,740. 77,101. 76,468. 62,8(C_{2-5}); (C-6); 127, 160-137,031 (C_6H_5); 177,5(RO-CO-CH_3) (for the 3rd substance).

The bactericidal properties of compounds were tested against the following microorganisms ─ Bacilus subtilis, Streptomyces albogriseolus, Pseudomonas Fluorescens, Pseudomonas tumelaciens [5,6]. Streptomyces albogriseolus was cultured in Krasilnicovs medium containing (KNO_3-1g, starch – 20g, agar – 20g). Bactericidal properties were assessed by a well method in terms of the zones of sterility around each well. Control consisted of solvent (ethanol-chloroform, 1:1). Substances were loaded into wells at concentrations of 0,001-0,1g/liter. Test substances were found to inhibit the growth of the study microorganisms. It should be noted that compound gave more active inhibition of the growth and development of study microorganisms, apparently because of the presence of a β-D-glucopyranose residue in the molecule.

Table 2. *Glucozides sulfur (3) the impact Growth of microorganismes*

Test-organisms	Concentration of substances%		
	0,1	0,01	0,001
	inhibition zone mm		
Bacilus subtilis	2,0	0	0
Streptomyces albogriseolus	2,0	0	0
Pseudomonas Fluorescens	3,0	1,0	1,0
Pseudomonas tumelaciens	5,0	3,0	1,0

With the help of computer program PASS Online [7-9]. PASS (Prediction of Activity Spectra for Substances) Online predicts over 4000 kinds

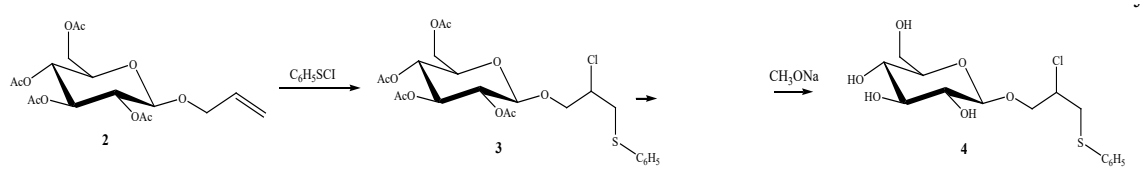


Table 1. *Characteristics 2,3,4,6-tetra-o-acetyl-1-O-(2-chloro-3-phenyl thio propyl)-β-D-Glucopyranose*

Brutal-formule	melting point t ^{0}C	Rf	Molecular mass	$[\alpha]^t{}_D$ $CHCI_3$	Outcome	
					Gr	%
$C_{23}H_{29}O_{10}SCI$	76 ^{0}C	0,51	532,5	$+8^0(t=20^0)$	1,4	51.8%

of biological activity, including pharmacological effects, mechanisms of action, toxic and adverse effects, interaction with metabolic enzymes and transporters, influence on gene expression, etc.

Computer program Evaluated Estimated Biological Activity 2,3,4,6-tetra-o-acetyl-1-O-(2-chloro-3-*phenyl thio propyl*)-β-D-Glucopyranose (3) (Table 3.) and his deacetylated product-1-O-(2-chloro-3-*phenyl thio propyl*)-β-D-glucopyranose (4)

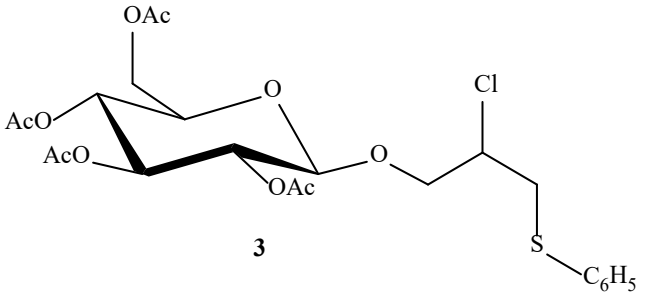


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Table 3. *2,3,4,6-tetra-o-acetyl-1-O-(2-chloro-3-phenyl thio propyl)-β-D-Glucopyranose*

Activity	Pa*	Pi**
Benzoate-CoA ligase inhibitor	0,901	0,005
Cholesterol antagonist	0,851	0,004
Antineoplastic	0,847	0,007
Antileukemic	0,796	0,004
CDP-glycerol glycerophosphotransferase inhibitor	0,812	0,027
Membrane permeability inhibitor	0,753	0,020
Antineoplastic (breast cancer)	0,731	0,005
Antineoplastic (cervical cancer)	0,709	0,004
Mannotetraose 2-alpha-N acetylglucosaminyltransferase inhibitor	0,699	0,027
Immunosuppressant	0,679	0,019
Antifungal	0,639	0,014
Prostate cancer treatment	0,618	0,005
IgA-specific metalloendopeptidase inhibitor	0,609	0,014
Alkenylglycerophosphocholine hydrolase inhibitor	0,632	0,041
Antibacterial	0,566	0,011
Mycothiol-S-conjugate amidase inhibitor	0,565	0,013
Beta glucuronidase inhibitor	0,571	0,020
Nicotinic alpha4beta4 receptor agonist	0,594	0,043
Angiogenesis stimulant	0,550	0,008
Hypolipemic	0,554	0,029
Anaphylatoxin receptor antagonist	0,557	0,049
CYP2H substrate	0,576	0,079
Sugar-phosphatase inhibitor	0,534	0,073

**Pa (probability "to be active") estimates the chance that the studied compound is belonging to the sub-class of active compounds.*

***Pi (probability "to be inactive") estimates the chance that the studied compound is belonging to the sub-class of inactive compounds.*

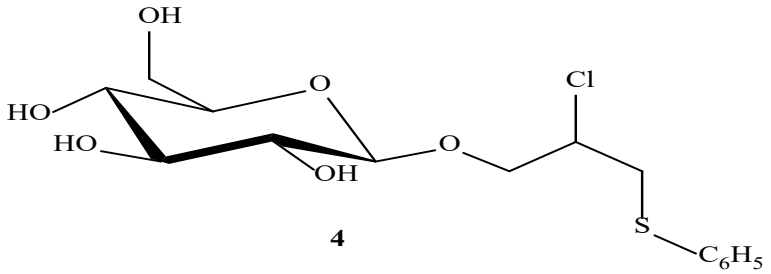

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Table 4. *1-O-(2-chloro-3-phenyl thio propyl)-β-D-glucopyranose*
Predicted activity spectrum

Activity	Pa	Pi
Benzoate-CoA ligase inhibitor	0,956	0,002
Alkenylglycerophosphocholine hydrolase inhibitor	0,956	0,002
IgA-specific metalloendopeptidase inhibitor	0,949	0,001
Sugar-phosphatase inhibitor	0,927	0,003
Cholesterol antagonist	0,923	0,002
Anthranilate-CoA ligase inhibitor	0,914	0,002
CDP-glycerol glycerophosphotransferase inhibitor	0,909	0,008
Fucosterol-epoxide lyase inhibitor	0,881	0,004
Licheninase inhibitor	0,877	0,001
Mycothiol-S-conjugate amidase inhibitor	0,834	0,002
Antileukemic	0,793	0,004
Antitoxic	0,770	0,004
Protein-tyrosine sulfotransferase inhibitor	0,766	0,003
Antineoplastic	0,771	0,015
Membrane permeability inhibitor	0,753	0,020
Vasoprotector	0,746	0,008
Angiogenesis stimulant	0,722	0,003
Sweetener	0,717	0,002
Cytostatic	0,714	0,009
Antineoplastic (cervical cancer)	0,708	0,004
Membrane permeability inhibitor	0,718	0,032
Antithrombotic	0,679	0,009
Lipotropic	0,659	0,005
Hepatoprotectant	0,641	0,010
Antineoplastic (breast cancer)	0,632	0,008
Beta glucuronidase inhibitor	0,612	0,012
Antifungal	0,602	0,018
Chitosanase inhibitor	0,591	0,007
Prostate cancer treatment	0,579	0,005
Antiinfective	0,574	0,015
Antibacterial	0,532	0,014
Antimetastatic	0,532	0,014
Immunostimulant	0,545	0,030
Antidiabetic	0,525	0,020
Hypolipemic	0,501	0,037

The estimation of pharmacological potential of compounds showed, that 1-O-(2-chloro-3-*phenyl thio propyl*)-β-D-glucopyranose (4) has a wider range of biological activity than 2,3,4,6-tetra-o-acetyl-1-O-(2-chloro-3-*phenyl thio propyl*)-β-D-Glucopyranose (3).

A comparison of the PASS predictions data showed, that similar biological activities: *Cholesterol antagonist, Sugar-phosphatase inhibitor, Mycothiol-S-conjugate amidase inhibitor, Beta glucuronidase inhibitor,* compound (4) has with higher Pa value than substance (3) and biological activity: *Antifungal, Prostate cancer treatment* is relatively low Pa.

Based on a generalization of a vast literary material, biologically active compounds are characterized by a certain specificity of composition and structure. Structural modification of compounds by introducing various molecules or atomic groups in a molecule can determine the effect of molecular separation of fragments on bioactivity.

Structural modification may change the toxicity of the drug, change the type of biological action or its prolongation.For example, compounds containing methyl-, ethyl-, phenyl- groups contain high antibacterial activity against gram-positive bacteria and yeast, however, this activity is reduced to fungi [10].

At the same time, it is known that phenolic compounds have a slight antibacterial activity. Compared to non-phenolic compounds. The authors [11] studied the effect of various paints of the Streptomycines genus of microorganisms; it turned out that the effectiveness of these compounds is due to the presence of aromatic rings in their structure.An increase in the hydrocarbon chain in a complex organic compound leads to an increase in physiological activity, the introduction of the group increases the effect of the substance in the respiratory center, the introduction of carbohydrate fragments into the molecule increases the synthesis of the compound, changes in the biological membrane, reduces toxicity, and so on.

In our case, the biological activity in compound 4 determines the acetylated groups, which may be the result of spatial exposure. Additional information about the biological spectrum will be further confirmed.Using the PASS onlainis computer program, the toxic effects of the synthesized substances were determined (3,4).

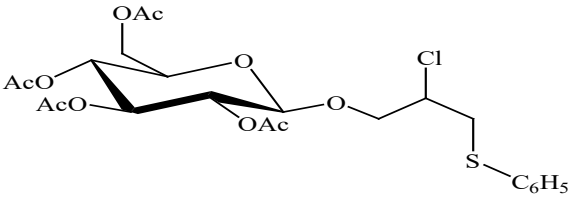

Table 5. *Possible adverse & toxic effects for compound 3 (prediction is based on clinical manifestation, which are sometimes observed in a few or even in a single patient)*

Possible adverse & toxic effects	Pa	Pi
Weakness	0,892	0,008
Diarrhea	0,889	0,012
Muscle weakness	0,859	0,009
Neurotoxic	0,840	0,013
Toxic	0,837	0,021
Drowsiness	0,815	0,019
Sleep disturbance	0,747	0,032
Conjunctivitis	0,725	0,032
Hematotoxic	0,710	0,040
Toxic, gastrointestinal	0,703	0,044

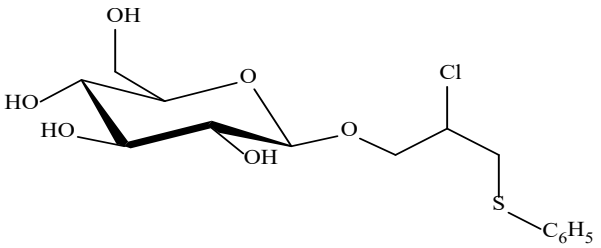

Table 6. *Possible adverse & toxic effects for compound 4 (prediction is based on clinical manifestations, which are sometimes observed in a few or even in a single patient)*

Possible adverse & toxic effects	Pa	Pi
Diarrhea	0,907	0,010
Neurotoxic	0,885	0,007
Dyspnea	0,860	0,009
Toxic, gastrointestinal	0,817	0,023
Fatty liver	0,797	0,004
Drowsiness	0,809	0,020
Hematotoxic	0,803	0,026
Behavioral disturbance	0,791	0,025
Toxic	0,791	0,029
Weakness	0,782	0,021
Sleep disturbance	0,777	0,027
Hyperglycemic	0,743	0,019
Coma	0,733	0,016
Anemia	0,724	0,023
Nausea	0,731	0,035
Embryotoxic	0,708	0,021

The results show that 1-O-(2-chloro-3-*phenyl thio propyl*)-β-D-glucopyranose (4) has a wider range of Toxic effect then 2,3,4,6-tetra-o-acetyl-1-O-(2-chloro-3-*phenyl thio propyl*)-β-D-Glucopyranose (3). Comparison of obtained datasimilar Toxic effect of substance (4) and substance (3): Diarrhea,

Neurotoxic, Toxic gastrointestinal, Drowsiness, Hematotoxic, Toxic, Weakness, Sleep disturbance. At the same time, substance 4 was diagnosed with Diarrhea, Neurotoxic, Toxic gastrointestinal, Hematotoxic, Toxic, Weakness, Sleep disturbance, the higher Pa values of toxic effects than substance 3. While the toxic effect of drowsiness is relatively low Pa.

Conclusion

From a theoretical and practical point of view, it is especially interesting to establish some correlation between structure and biological activity, which serves to search for the biological properties of new compounds with preliminary predictions. Identify the biologically active groups in the substance, determine which fragment is the biological activity of the compound. Our goal is to serve this goal.

By assessment of structure-activity relationships biological activity spectrum of synthesized glycosides have been revealed. The results of the study will enable us providing selection of the most prospective compounds from the set of synthesized samples.

References

[1] G. Elgemeie, N. Fathy, W. Zaghary &A. Farag, S-glycosides in medicinal chemistry: Novel synthesis of cyanoethylene thioglycosides and their pyrazole derivatives, J. Nucleosides, Nucleotides and Nucleic Acids, 36, 3 (2017)198-212.

[2] N.N. Sidamonidze, R.O. Vardiashvili, K.Z. Onashvili, L.V. Tabatadze, Synthesis and Bacte ricidal Properties Sulfur-Containing 1,2-Trans-Glycosides; Black Sea Scientific J. Of Academic Research. Eesti, Tallin, 41, 0,3 (2018) 35-44.

[3] L.V. Tabatadze, N.N. Sidamonidze, N.O. Pirveli, R.A. Gakhokidze, Synthesis of Some Sulfur-containing derivatives of disaccharides. Chemistry of Natural Compounds, Academy of Sciences of the Republic of Uzbekistan, 5 (2005) 484-486.

[4] L.V. Tabatadze,R.A. Gakhokidze, Z.SH. Lomtatidze, N.N. Sidamonidze, N.A. Sabauri, Synthesis and Antimicrobial Activity of Sulfur-containing Glycosides, J. Pharmacevtical Chemistry, 41,8 (2007)11-12 (In Russian).

[5] N.N. Sidamonidze, R.A. Gakhokidze, N.A. Sabauri, Z.Sh. Lomtatidze, Synthesis and biolo gical Activity of some derivatives of selenoglucosides. Chemical of Heterocyclic Compoundes. 45,8 (2009)1167-1171.

[6] N.N. Sidamonidze, R.O. Vardiashvili, M.O. Isakadze, L.K. Djaniashvili, Z.Sh. Lomtatidze, Boilogical Activity of some Aldose-containing compounds. Pharmaceutical Chemistry J. 41, 3 (2007) 131-132.

[7] D.A. Filimonov, D.S. Druzhilovsky, A.A. Lagunin, T.A. Gloriozova, A.V. Rudik, A.V. Dmitriev, P.V. Pogodin, V.V. Poroikov, Computer prediction spectrum of biological activity of chemical compounds: opportunities and constraints, Biomedical Chemistry: Research and Methods 1 (2018)1-21 (In Russian).

[8] E. Czerepak, S. Ryser, Drug approvals and failures, implications for alliances, Nature Re views Drug Discovery, 7 (2008) 197-198.

[9] L.Ruddigkeit, L.C. Blum, J.L. Reymond, Visualization and virtual screening of the chemical universe database GDB-17, J. of Chemical Information and Modeling, 53,1 (2013) 56-65.

[10] S.K.Basu, I.E Chattopadhyay, Sintesis and antibacterial evaluation of some phenolican tiseptic salts of 9-aminoacridine. I. Inst chem. (India), 58, 6 (1996) 201-215.

[11] I.I. Rodionova, V.N. Danilenko, Factors of genetic instability of streptomycetes and their use in genetic-selective practice. Antibiotic sand chemotherapy. 33,3 (1988)171-177 (In Russian).

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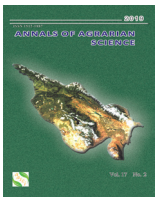

Mineral element content of some Georgian wines

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A B S T R A C T

The purpose of this study was to determine mineral element composition in three selected wine samples (Aladasturi, Chkhaveri and Tsolikouri) produced in Adjara region of Western Georgia. All sample wines are made from grapes variety grown in Adjara region and were from 2015 to 2017 vintages. Plasma-atomic emission spectrometer ICPE-9820 has been used for qualitative and quantitative determination of the elements in the required concentration range, because of a high sensitivity, a wide dynamic range and a high sample throughput of this spectrometer. The ICPE-9820 provides axial view plasma observation in a direction coaxial to the plasma, and in addition to axial view, provides radial view plasma observation in the perpendicular direction. This dual view capability allows measurements to switch automatically between high-sensitivity axial view and high-accuracy radial view, enabling analysis of elements across a broad concentration range with a single method. In this study, sixteen mineral elements (Al, Ba, Ca, Cu, Fe, K, Mg, Mn, Na, Zn, Ni, Pb, Cd, Co, Cr and Li) were analyzed. The analysis was performed by diluting wine samples 10 times with deionized water, without any prior preparation, followed by sequential determination of the elements by ICPE. The higher concentrations were noted for major elements as follows: potassium, magnesium, calcium, sodium and iron. The lowest concentrations were noted for minor elements: manganese, aluminium, barium, zinc and copper. Such trace elements as nickel, chromium and lithium were found under the limit of quantitation. Plumbum, cadmium and cobalt were under the limit of detection. Analyzing concentration levels of elemental composition, it can be concluded that depending on the color of the wine, the content of the individual element was different. Data obtained showed that none of the wine samples surpassed the toxic levels reported for metals in the literature and were within the allowed metals levels in wines for human consumption.

Keywords: major elements, minor elements, concentration, multielement analysis, wine, ICPE-9820.

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Introduction

Georgia is one of the oldest winemaking nations in the world and by some experts even considered as the birth-place of wine. This is supported by 8000 years old archeological findings of grape-stones inside antique clay pots. In Georgia the conditions are well suited for winemaking, as the climate is moderate and extreme weather conditions are rare. The summers are not too hot and the winters are mild. Also, the surrounding mountains are full of natural springs, with rivers providing mineral-rich waters into the valleys. Nowadays, approximately 530 native Georgian sorts of grapes are known. More than 425 sorts are preserved today and are kept is special nurseries. 30-35 sort of Georgian grapes are used today in wine production [1].

A lot of scientific researches have been conducted to confirm that the moderate consumption of wine improves good health and longevity when it is combined with a balanced diet [2]. Wine is a complex matrix and it contains low level concentration of mineral elements. Determination of the mineral element content of wines is important for many reasons. Firstly, the concentration of elements in wine is useful information to vine grower and oenologists for controlling the process of obtaining high and quality wines, also the element content could be used as a wine fingerprint and represents one of the criteria for evaluating the authenticity of wine [3,4]. Secondly, their content should be determined and controlled, because excess is undesirable, and in some cases prohibited, due to potential toxicity. In

addition, the wine industry does not require control of the metal content in wine, thus, the knowledge of their content in this alcoholic beverage is very important [5-7].The level of the major elements (Ca, K, Na, Mg and Fe) that are related to the grape variety and maturity, type of soil in the vineyard, and ecoclimatic conditions, usually ranges between 10 and 1000 mg/L. The minor elements (Al, Cu, Mn, Ba, and Zn) depends on external impurities during the growth of grapes and vinicultural and winemaking practices, are present in the range of 0.1 to 10 mg/L. Trace elements (Cd, Co, Cr, Ni, Li and Pb) are in the range of 0.1-1000 μg/L [8]. Some factors, such as application of fungicides, pesticides and fertilizers during the growing season, can lead to an increase these elements in wine [9-11]. The allowed levels of metal in wines are prescribed by the International Organization of Vine and Wine (OIV) [12].

The goal of this study is to measure and analyze the mineral components in three selected wine samples (Aladasturi, Chkhaveri and Tsolikouri) produced in Adjara region of Western Georgia. Inductively coupled plasma-atomic emission spectrometer (ICPE-9820) was used for qualitative and quantitative determination of mineral elements in wine samples [13].

Materials and Methods

Three samples of wines, including one sample of red wine (Aladasturi), one sample of rose wine (Chkhaveri) and one sample of white wine (Tsolikouri) were analyzed. All sample wines are made from grapes variety grown in Adjara region and were from 2015 to 2017 vintages. Aladasturi is dry red wine made from Aladasturi grapes, cultivated in Western Georgia. Wine has pomegranate color and is characterized with distinctive bouquet and harmonious taste. Chkhaveri is dry rose wine made from rare Georgian grape variety – Chkhaveri, harvested in mountainous area of Adjara region. Chkhaveri is described as light and pleasant wine in "Ampelography of Georgia" – a book issued in 1960, being one of the most valuable books in Georgian winemaking. Nowadays, wine professionals and winemakers fairly think that such interpretation is not sufficient and Chkhaveri varietal needs further observation and research. Tsolikouri, dry white wine, has been manufactured since 1890. The wine made from grapes variety of the same name cultivated in Western Georgia. Tsolikouri is of pale-straw colour and has strong bouquet, at fresh harmonious taste. The alcohol in each wine samples ranges from 10 to 12.5%vol, sugar - from 18 to 22% and titratable acidity - from 7 to 9‰ [1].

For the determination of elemental composition of wines, it is required to properly prepare the samples. Taking into consideration that wine is a complex water-ethanol mixture, containing various inorganic and organic substances at different levels, the sample preparation stage is very important in the analysis of particular wine components. The wine samples have been simply diluted 10 times with deionized water, without any prior preparation. It was sufficient for the elimination of matrix effects, especially the amount of salts and organic components introduced into the ICP plasma. Lower dilution factors significantly hindered determination of elements in wine samples. The similar observation was found in the study of wine analysis by A.Gonzálvez [14]. The containers used for storage or treatment of the samples were cleaned to avoid contamination with any metals. The containers were treated with nitric acid and washed with deionized water [14,15].

The ICPE-9820 spectrometer (Shimadzu, Japan) was used for the analysis of sixteen elements (Al, Ba, Ca, Cu, Fe, K, Mg, Mn, Na, Zn, Ni, Pb, Cd, Co, Cr and Li) in selected wine samples.

The Shimadzu ICPE-9820 is a simultaneous spectrometer with CCD (charge-coupled device) detector, which has been used for all determinations. The ICPE-9820 provides axial view plasma observation in a direction coaxial to the plasma, and the radial view plasma observation in the perpendicular direction. This dual view capability allows measurements to switch automatically between high-sensitivity axial view and high-accuracy radial view, enabling analysis of elements across a broad concentration range with a single method. This series features Shimadzu's mini-torch system and Eco mode, which reduces argon gas consumption and power consumption during measurement standby by approximately half in comparison to previous models. Furthermore, performance is ensured even with 99.95 % pure argon gas, not the 99.999 %, or purer gas generally used for ICP systems which helps to reduce operating costs. In addition, a vertically-oriented torch reduces memory effects and shortens rinse time. The adoption of this torch and vacuum spectrometer enables highly stable, high-throughput analysis. ICPE solution control software features intuitive operation for easy creation and optimization of complicated methods, allowing for a smooth

analysis process from the start [14,16,17]. Table 1 shows a summary of the system parameters and the analytical lines for each element are shown in table 2.

For spectrometry measurements, series of calibration solutions with proper concentrations were made. For calibration solution preparations following standards (Sigma-Aldrich, Switzerland) were used:

-Multielement Standard Solution 6 for ICP, 100mg/L each element in 5% HNO_3;

-Internal Yttrium Standard (Y) for ICP, 1001 mg/L±4mg/L in 2% HNO_3.

1% HNO_3 was used to prepare calibration standards immediately before usage. Concentrations of calibrations were from 5µg/L to 5 mg/L for every element and 0.1mg/L for an internal yttrium standard.

Deionized water with the maximum resistivity of 18.2 MΩ/cm obtained from the Purity Labwater system D340 (Oxfordshire, United Kingdom) were used for sample pretreatment and dilution. All the solutions were prepared in high-density polyethylene containers and were of analytical reagent grade [14].

Table 1. *ICPE-9820 instrumental parameters for determination of elements in wine*

Parameters	Setting
Radio frequency power	1.20 kW
Gas Type	Argon
Argon	6 L/min
Gas purity	99.95%
Auxiliary gas	0.60 L/min
Plasma gas	7.00 L/min
Carrier gas	0.70 L/min
Nebulizer	Coaxial
Plasma observation	Axial/Radial
Detector	CCD (charge coupled device)
Spectral range	167 – 800 nm
Exposure time	15 sec.
Attached Instrument	Mini-torch

Table 2. *The analytical lines for determination of each element*

Elements	Detection wavelength (λ/nm)
Aluminium	396.153
Barium	455.403
Calcium	315.887
Copper	327.396
Iron	259.940
Potassium	766.490
Magnesium	383.231
Manganese	344.297
Sodium	589.592
Zinc	213.856
Nickel	231.604
Plumbum	220.353
Cadmium	226.502
Cobalt	237.862
Chromium	206.149
Lithium	610.364

Result and discussion

This research was intended to characterize the wine samples (Aladasturi, Chkhaveri and Tsolikouri) produced in Adjara region and made from different types of grapes, in terms of metals content. Sixteen elements were analyzed by plasma-atomic emission spectrometer (ICPE-9820). The method proposed is simple and sensitive, allowing the adequate and simultaneous determination of major and minor elements by ICPE. Depending on the elements, their quantity varied in wine from µg/L to mg/L. It needs to be noted that all metals content in the analyzed wine samples was much smaller than the maximum concentrations permitted according to the OIV [12].

Major elements like potassium, magnesium, calcium, sodium and iron were abundant in our wine samples (Table 3). The concentration levels of these elements in our study were close to the values found in other researches [18,19,20,21].

Potassium exhibited higher concentrations (255 to 425 mg/L) than the rest of the elements in our wine samples. The highest level of K (425 mg/L) was detected in the white wine (Tsolikouri). Potassium is the main positive ion in wine. A number of factors affect the amount of potassium in wine, including the variety of grapes, soil and climatic conditions, time of harvest, the temperature of fermentation and storage, and the pH and he use of ion-exchange resins. The high level of potassium in wine has great nutritional values.

Magnesium was detected in concentrations between 77.2 mg/L to 110 mg/L in our wines. Red wine (Aladasturi) contents higher concentration of magnesium (110 mg/L). Magnesium content in wines correlates with the natural Mg content of grapes, its content also can be attributed to a number of factors including the soil composition, pH, the time and temperature of storage, and the rate of pressing.

Calcium, sodium and iron were 57.7 to 80 mg/L, 1.77 to 5.51 mg/L, 1.43 to 4.26 mg/L, respectively, in wine samples. High concentration levels of these elements were in rose wine sample (Chkhaveri). Vineyard soil is a natural source of calcium in musts, however, wines with a calcium level above 80 mg/L are considered to be at risk of instability. However, calcium leads to no problems under normal circumstances, and the fining process can be a pathway for calcium entry in wine. Sodium is the main extracellular cation. It participates in the maintenance of the acid-base balance and in osmotic regulation. This principal component can be related to soil composition and winemaking process. Iron play an important role in chemical processes with acetaldehyde, it catalyzes acetaldehyde combination with phenol compounds.

Minor elements such as manganese, aluminium, barium, copper and zinc were found in lowest concentrations (0.48 to 1.07 mg/L, 0.42 to 1.22 mg/L, 0.42 to 0.57 mg/L, 0.14 to 0.46 mg/L, and 0.14 to 0.38 mg/L, respectively) that were under Maximum Permissible Limits (MPL). The results revealed the trace elements concentration such as nickel, chromium, lithium to be extremely low, under the limit of quantitation (ULOQ) (<0.0105µg/L, <0.0162µg/L, <0.0792µg/L, respectively) in our wines. Plumbum, cadmium and cobalt were under the limit of detection (ULOD) (Table 3). This can be explained by the limited industrialization in the area grapes were cultivated.

Figures 1-5 demonstrate the calibration curves of major and minor elements (K, Mg, Ca, Na, Fe, Mn, Al, Ba, Zn and Cu). The calculated calibration curves show good linearity range for all tested analytes with coefficient of determination in the range from 0.974 to 0.999; limit of quantity (LOQ) and the limit of detection (LOD) for each element were obtained.

Figures 6-9 show the spectral lines of major and minor elements in selected wines (Aladasuri, Chkhaveri and Tsolikouri).

The results of quantitative analysis of elemental concentrations in different wine samples determined by ICPE-9820 are listed in Table 3.

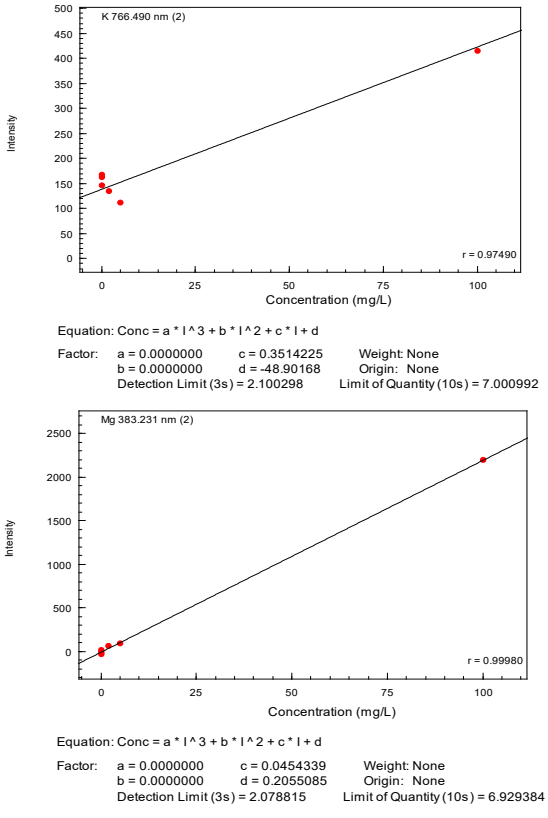
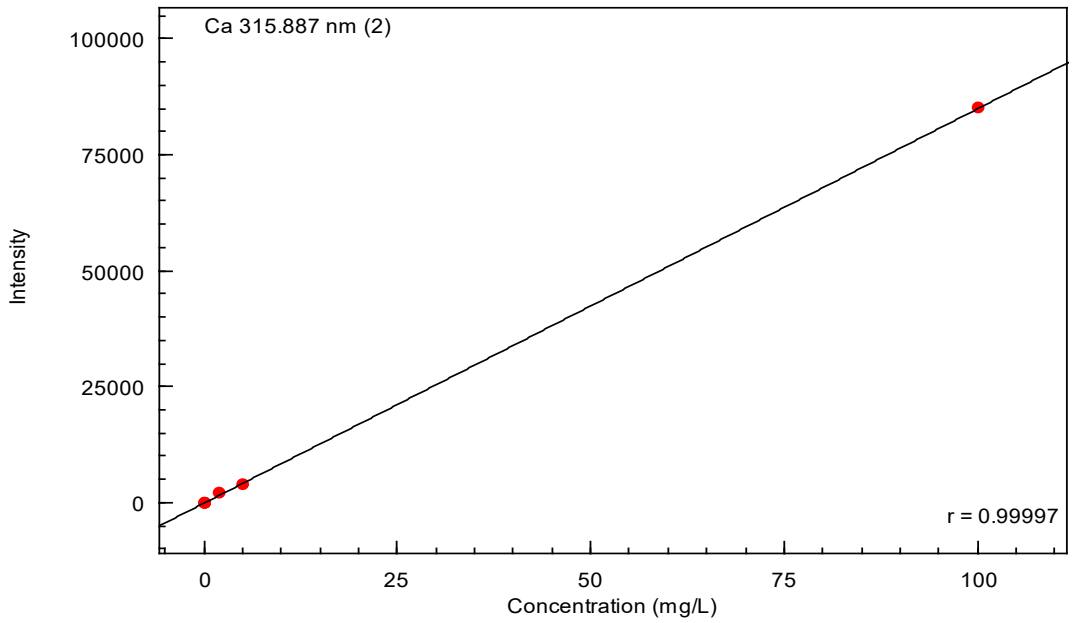


Fig. 1. *The calibration curves of major and minor elements*



Equation: Conc = a * I ^ 3 + b * I ^ 2 + c * I + d

Factor: a = 0.0000000 c = 0.0011753 Weight: None
b = 0.0000000 d = -0.0402528 Origin: None
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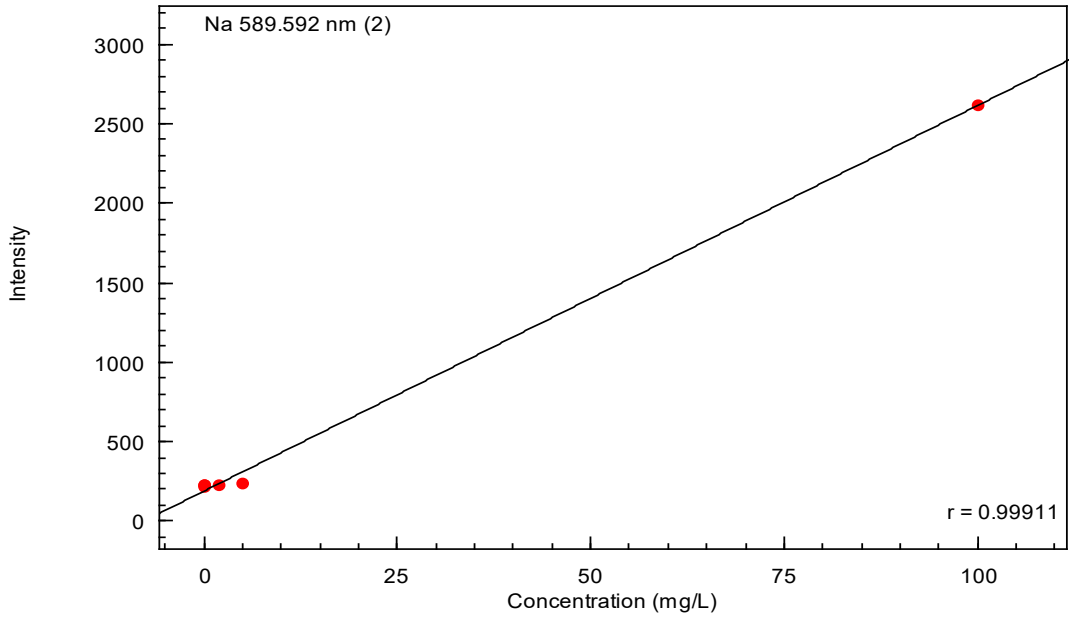

Equation: Conc = a * I ^ 3 + b * I ^ 2 + c * I + d

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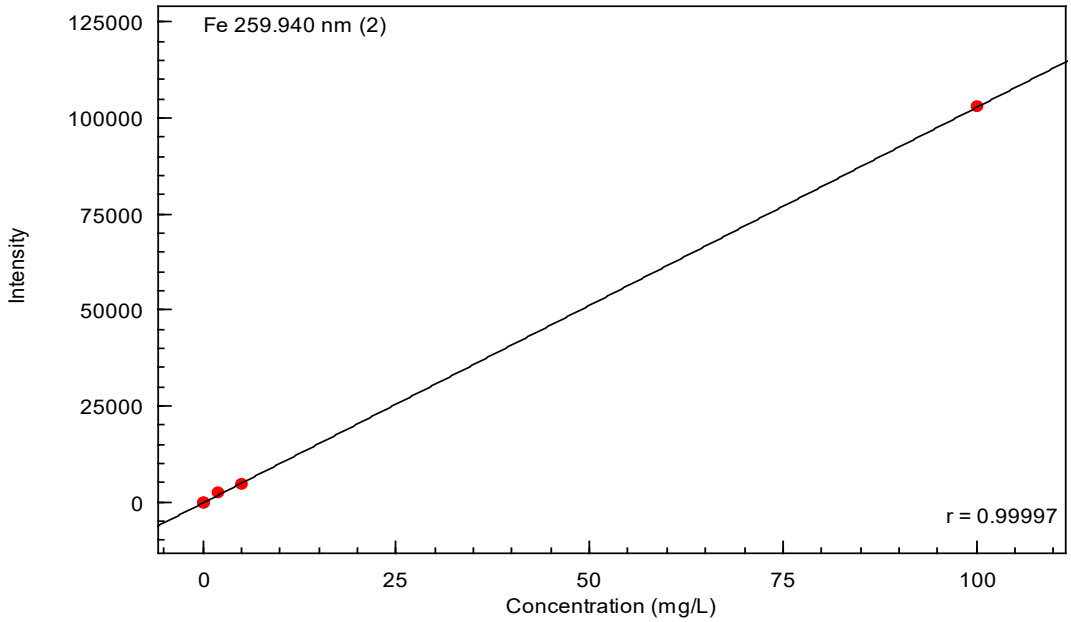
Fig. 2. *The calibration curves of major and minor elements*



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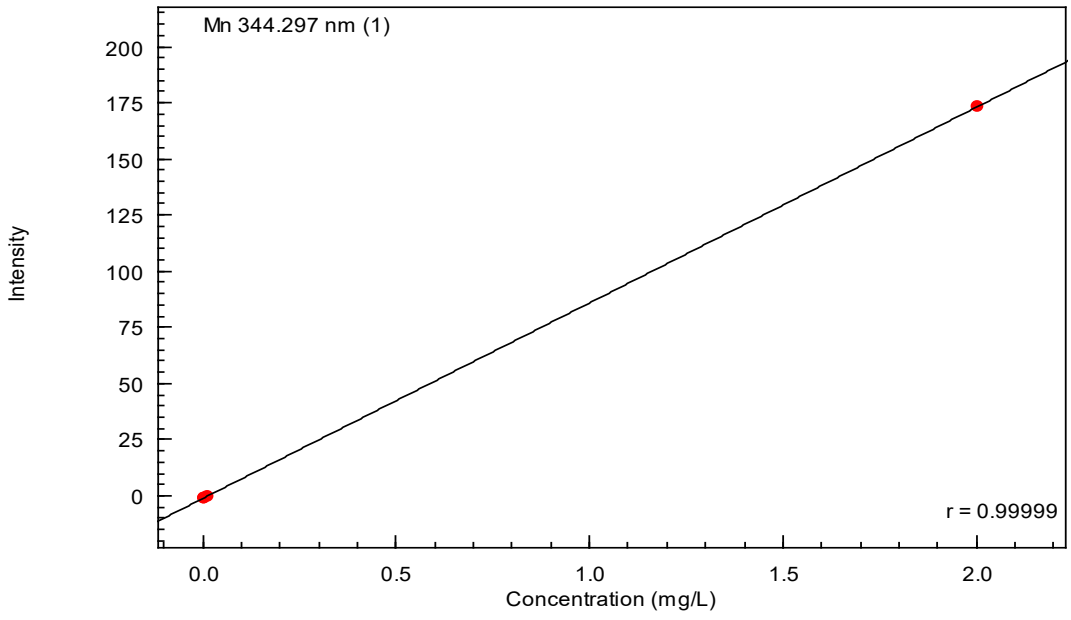

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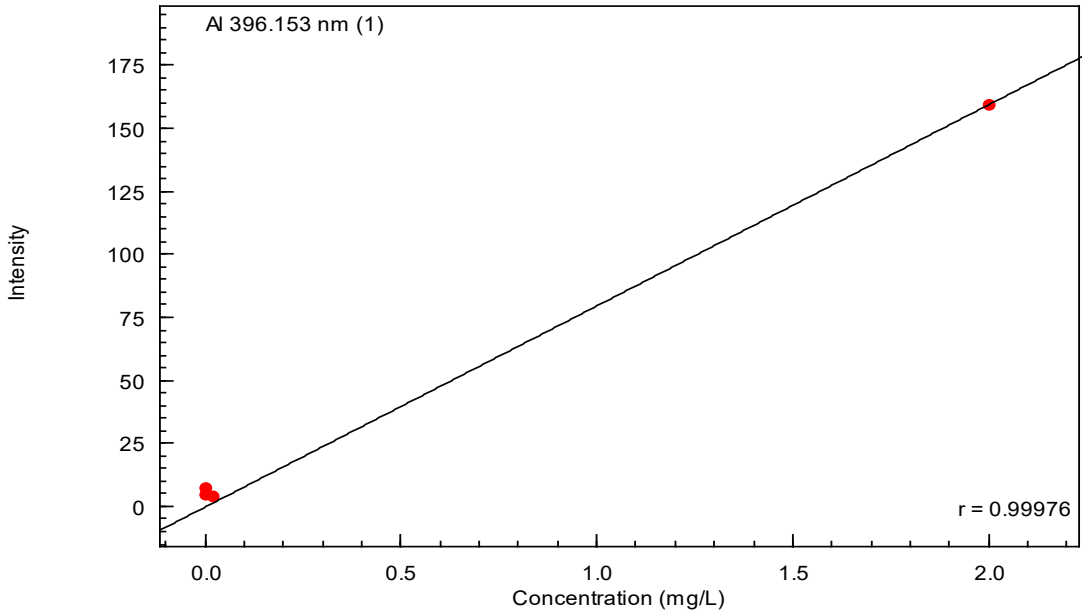
Fig. 3. *The calibration curves of major and minor elements*



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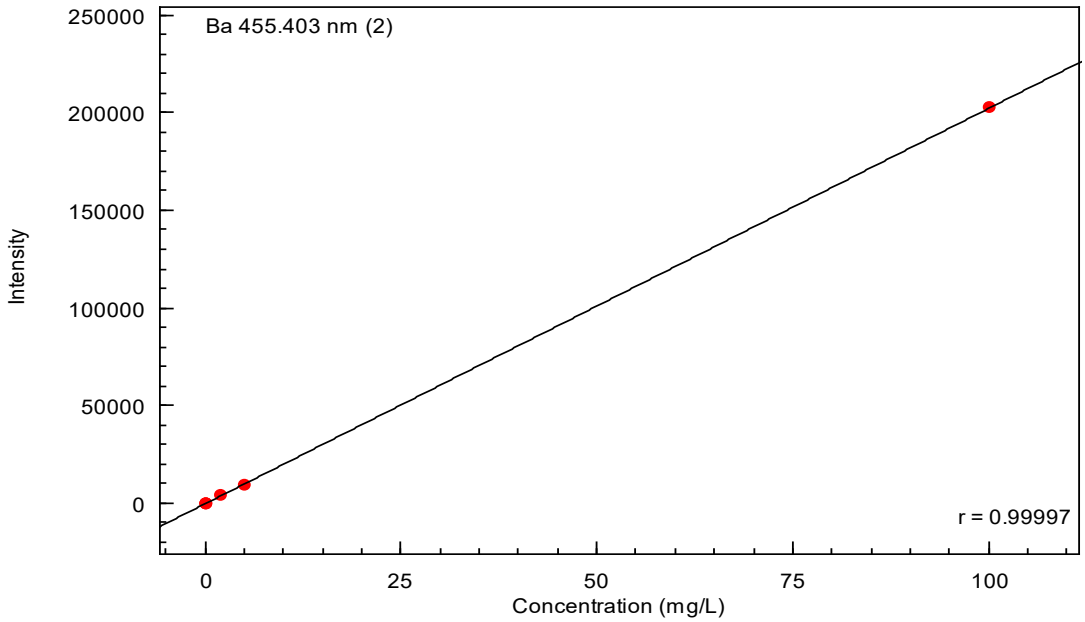

Equation: Conc = a * I ^ 3 + b * I ^ 2 + c * I + d

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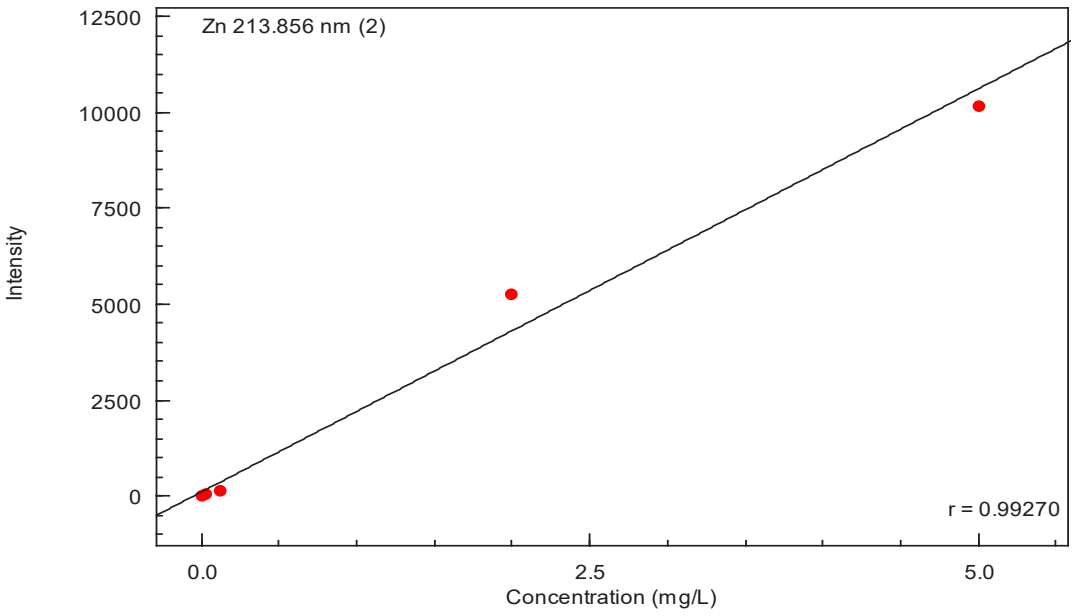
Fig. 4. *The calibration curves of major and minor elements*



Equation: Conc = a * I ^ 3 + b * I ^ 2 + c * I + d

Factor: a = 0.0000000 c = 4.755525e-004 Weight: None
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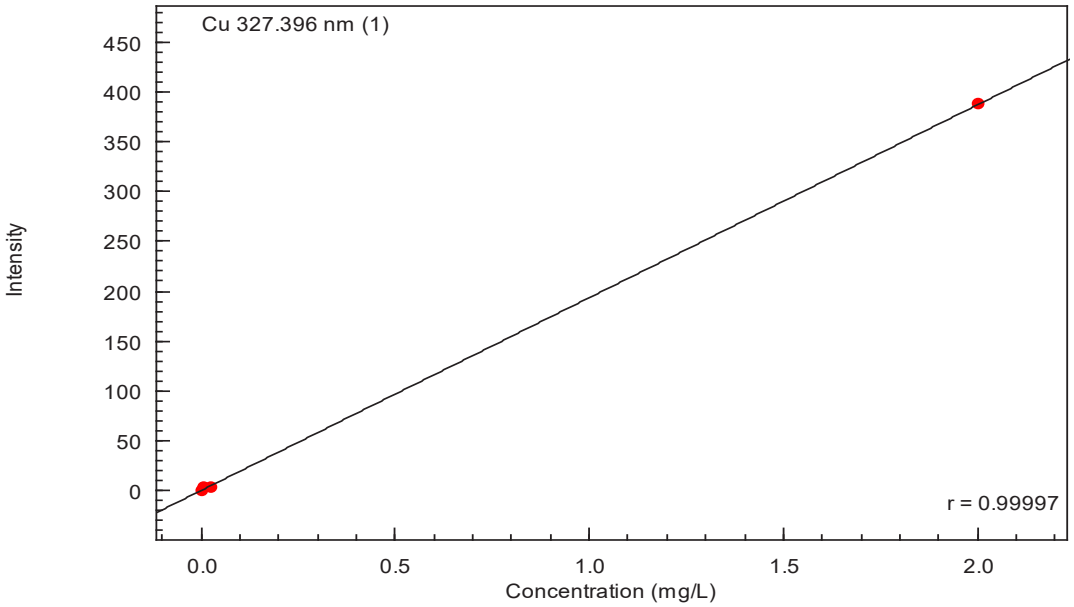

Equation: Conc = a * I ^ 3 + b * I ^ 2 + c * I + d

Factor: a = 0.0000000 c = 0.0051703 Weight: None
b = 0.0000000 d = -0.0047623 Origin: None
Detection Limit (3s) = 6.711194e-004 Limit of Quantity (10s) = 0.0022371

Fig. 5. *The calibration curves of major and minor elements*

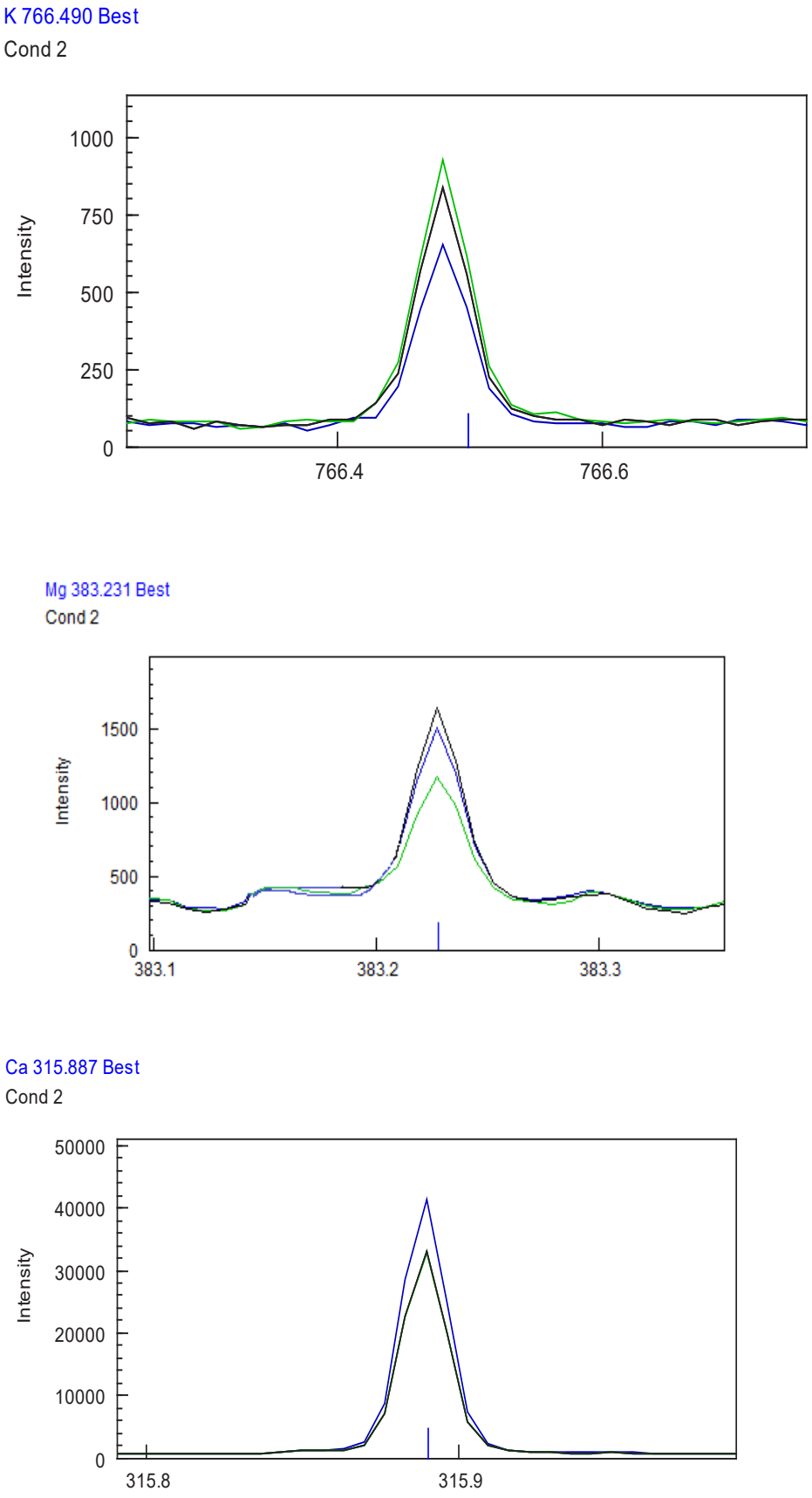

Fig. 6. *The spectral lines of major and minor elements in wine samples (Aladasturi, Chkhaveri, Tsolikouri)*

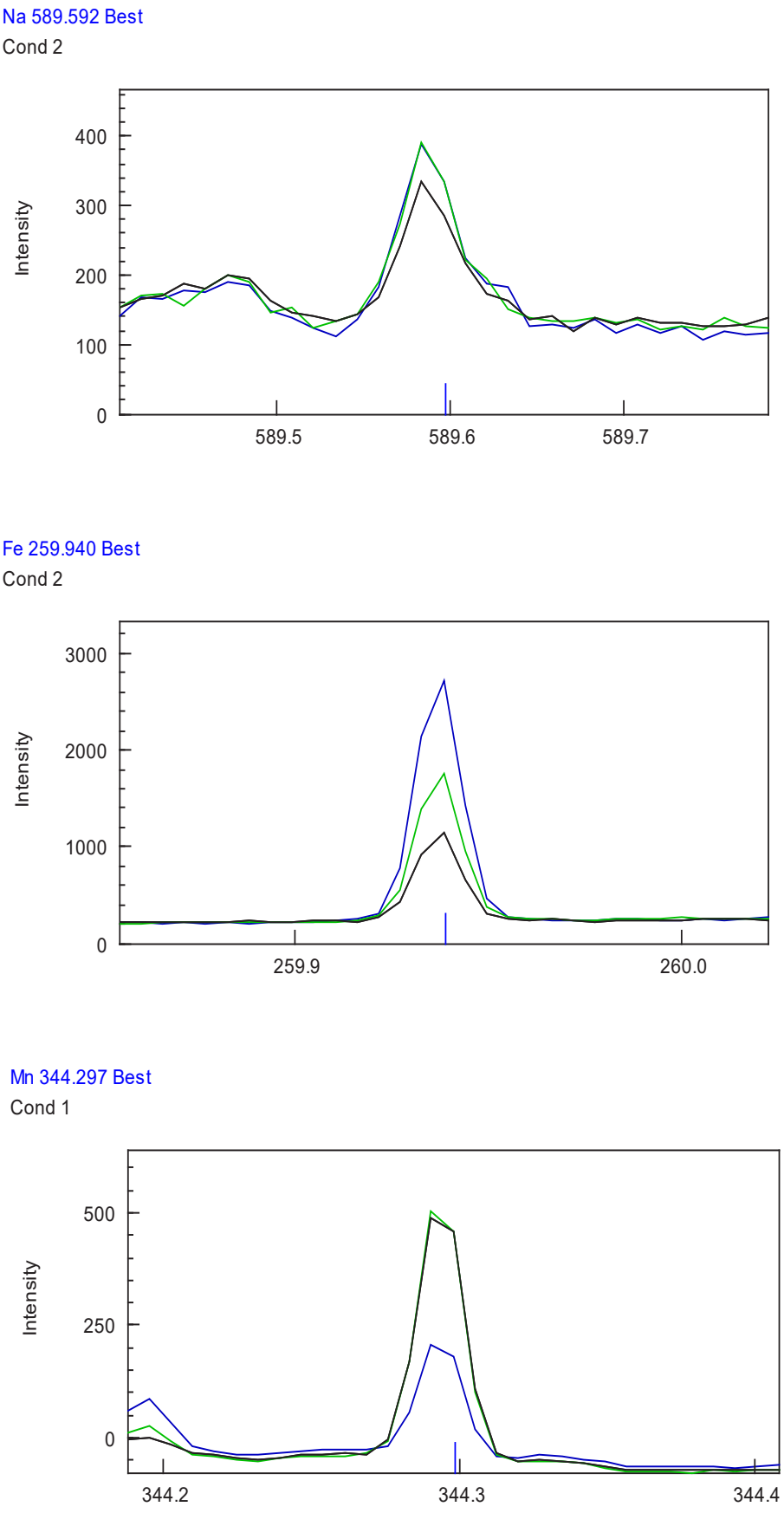

Fig. 7. *The spectral lines of major and minor elements in wine samples (Aladasturi, Chkhaveri, Tsolikouri)*

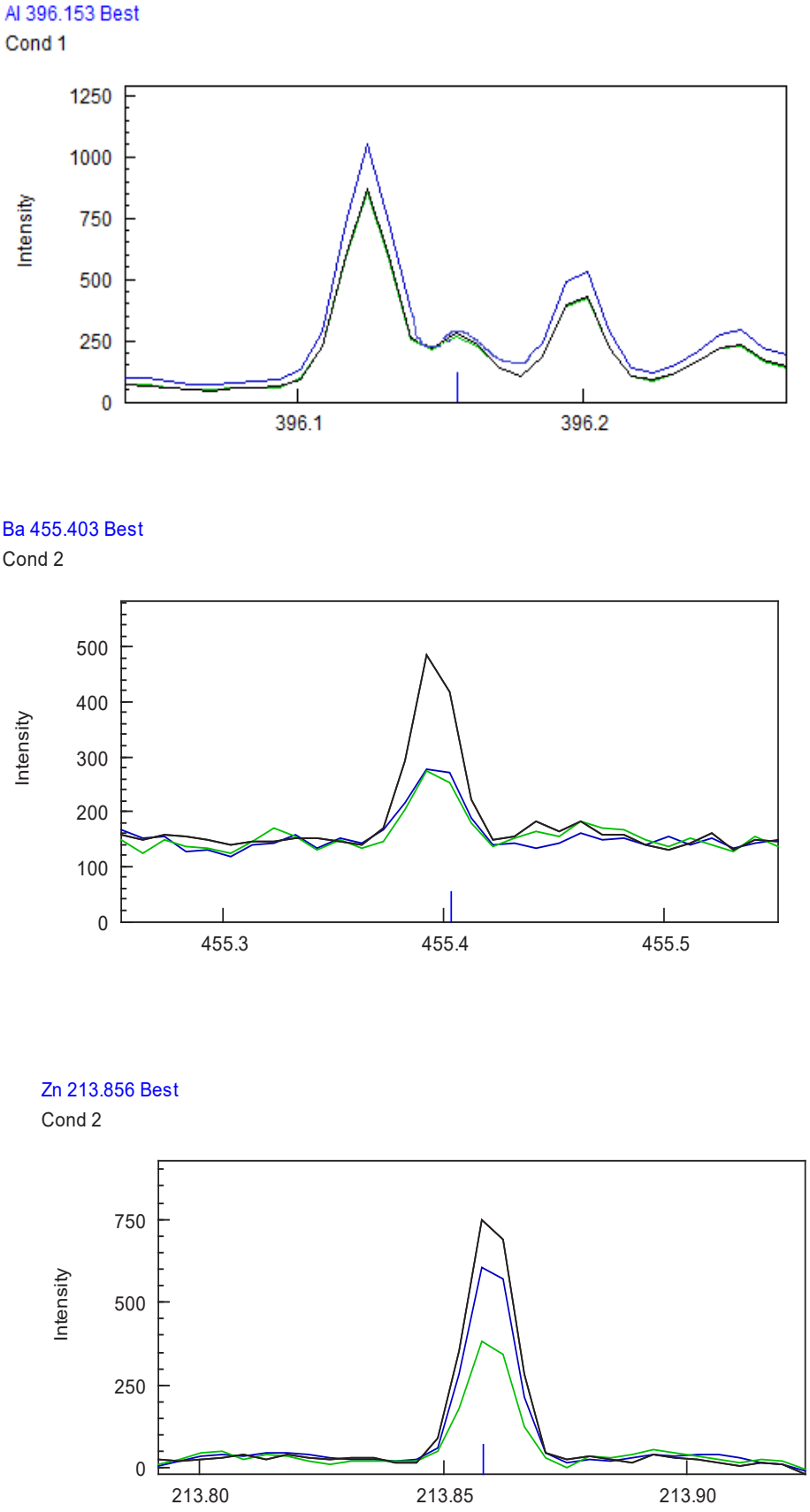

Fig. 8. *The spectral lines of major and minor elements in wine samples (Aladasturi, Chkhaveri, Tsolikouri)*

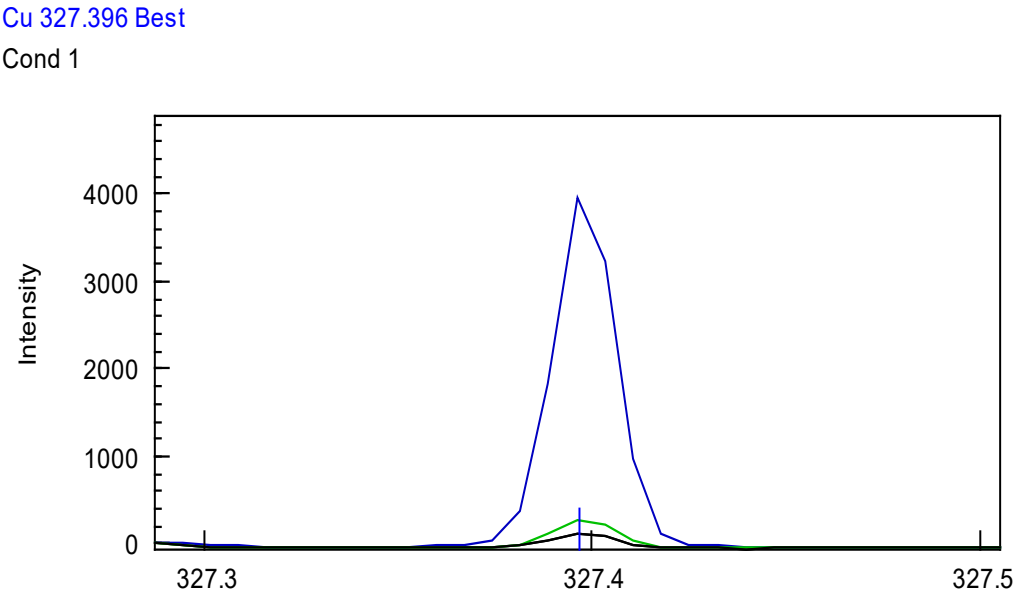

Fig. 9. *The spectral lines of major and minor elements in wine samples (Aladasturi, Chkhaveri, Tsolikouri)*

Table 3. *Element content of wine samples*

№	Element	Aladasturi (red wine)	Chkhaveri (rose wine)	Tsolikouri (white wine)
		Concentration (mg/L)		
1	Al	0.45	1.22	0.42
2	Ba	0.42	0.43	0.57
3	Ca	57.7	80.0	64.1
4	Cu	0.14	0.46	0.17
5	Fe	1.43	4.26	2.63
6	K	318	255	425
7	Mg	110	101	77.2
8	Mn	1.06	0.48	1.07
9	Na	1.77	5.51	5.35
10	Zn	0.38	0.33	0.14
		Concentration (µg/L)		
11	Ni	<0.0524	<0.0105	<0.0496
12	Pb	ULOD	ULOD	ULOD
13	Cd	ULOD	ULOD	ULOD
14	Co	ULOD	ULOD	ULOD
15	Cr	<0.0162	<0.0172	<0.0243
16	Li	<0.0792	<0.1250	<0.0938

ULOD –under the limit of detection

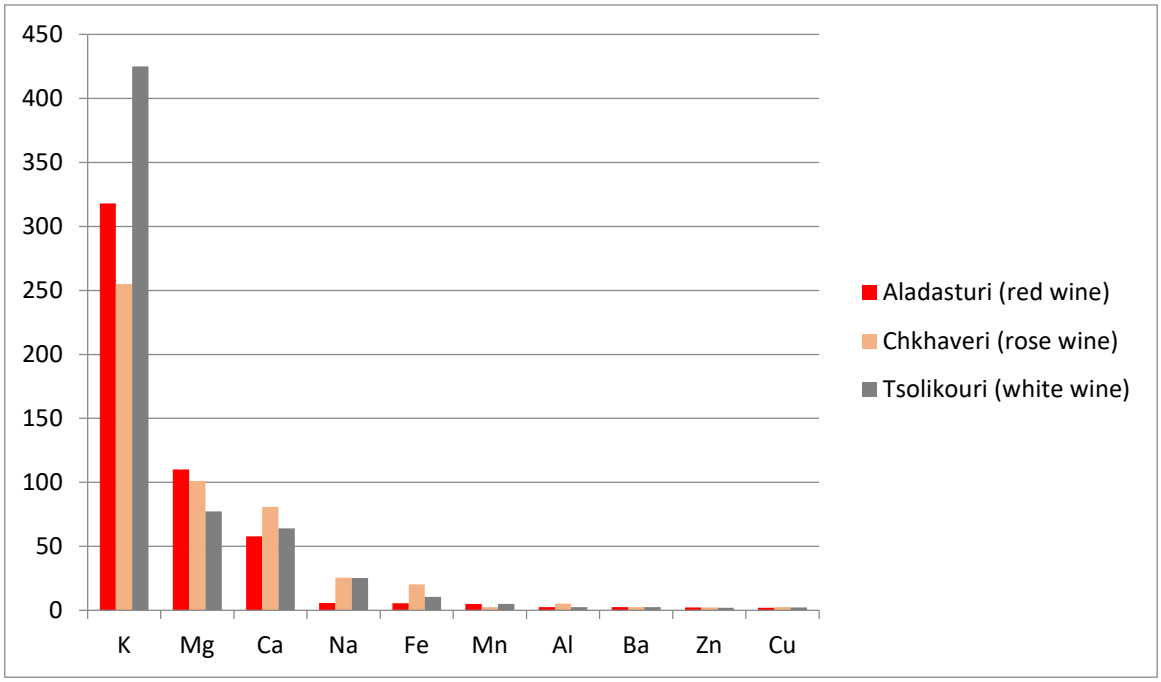

Fig.10. *Results for element concentration in the wine samples (in mg/L)*

Figure 10 clearly shows the ratio of major and minor elements in determined wines.

If relative abundances of the mineral elements in Aladasturi are compared, the tendency at the ranking is as follows: K>Mg>Ca>Na>Fe>Mn>Al>Ba>Zn>Cu;

in Chkhaveri – K>Mg>Ca>Na>Fe>Al>Mn>Cu>Ba>Zn;

in Tsolikouri – K>Mg>Ca>Na>Fe>Mn>Ba>Al>Cu>Zn.

These relations are similar in all selected wines: K>Mg>Ca>Na>Fe.

The following general conclusions can be made from data in Table 3:

-Magnesium and zinc content of red wine is higher than those of rose and white wines;

-Calcium, sodium, iron, aluminium and copper content of rose wine is higher than those of red and white wines;

-Potassium, manganese and barium content of white wine is higher than those of red and rose wines.

Analyzing concentration levels of determined mineral elements, it can be concluded that depending on the color of the wine, the content of the individual element is different.

Based on the amount of concentration in wine, the elements were classified into four categories:

- K, Mg, Ca, Na and Fe – elements in the high concentrations;
- Mn, Al, Ba, Zn and Cu - elements in the low concentrations;
- Ni, Cr and Li - under the limit of quantitation;
- Pb, Cd and Co - under the limit of detection.

Conclusion

Inductively coupled plasma-atomic emission spectrometer (ICPE-9820) has been used for qualitative and quantitative determination of sixteen mineral elements (Al, Ba, Ca, Cu, Fe, K, Mg, Mn, Na, Zn, Ni, Pb, Cd, Co, Cr and Li) in three selected wine samples (Aladasturi, Chkhaveri and Tsolikouri) produced in Adjara region of Western Georgia. The results show that ICPE-9820 is preferable for elemental determination in wine, for its fastness and simplicity of analysis. Moreover, multielement analysis using this spectrometer requires little sample preparation and gives good precision analysis with low detection limits.

Potassium, magnesium, calcium, sodium and iron quantitatively dominate in all determined wine samples. Manganese, aluminium, barium, zinc and copper have been under Maximum Permissible Limits (MPL). A remarkable finding of this study was that in all wine samples the heavy metals nickel, chromium and lithium have been under the limit of quantitation. Plumbum, cadmium and cobalt have been under the limit of detection. The established content of metals showed that none of our wine samples surpassed the toxic levels of metals as published by the OIV. Analyzing concentration levels of elemental composition, it can be concluded

that depending on the color of the wine, the content of the individual element was different.

References

[1] G. Papunidze, Production technologies and the characteristics of certain types of wines made from grape varieties spread in Adjara, J. Moambe - Academy of Agricultural Sciences of Georgia. 29 (2011) 54-58 (in Russian).

[2] D.M. Goldberg, I.L. Bromberg, Health effects of moderate alcohol consumption: a paradigmatic risk factor, J.ClinicaChimicaActa. 246 (1996) 1-3.

[3] S.M. Rodrigues, M. Otero, A.A. Alves, J. Coimbra, M.A. Coimbra, E. Pereira, A.C. Duarte, Elemental analysis for categorization of wines and authentication of their certified brand of origin, J. Food Compos Anal. 24 (2011) 548–562.

[4] J. Kristl, M. Veber, M. Slokovec, The contents of Cu, Mn, Zn, Cd, Cr and Pb at different stages of the winemaking process, J. ActaChimSlov. 50 (2003) 123-136.

[5] M. Álvarez, I.M. Moreno, A.M. Jos, A.M. Cameán, A.G. González, Study of mineral profile of Montilla-Moriles "fino" wines using inductively coupled plasma atomic emission spectrometry methods, J. Food Compos Anal. 20 (2007) 391–395.

[6] J.D. Greenough, L.M. Mallory-Greenough, B.J. Fryer, Geology and wine: Regional trace element fingerprinting of Canadian wines, J. Geosci. Can.32 (2005) 129–138.

[7] P. Pohl, What do metals tell us about wine?, J. Trends in Analytical Chemistry. 26 (2007) 941-949.

[8] S. Galani-Nikolakaki, N. Kallithrakas-Kontos, A.A. Katsanos, Trace element analysis of Cretan wines and wine products, J. Science of the Total Environment. 285 (2002) 155-163.

[9] D. Kostić, S. Mitić, G. Miletić, S. Despotović, A. Zarubica, The concentrations of Fe, Cu and Zn in selected wines from South-East Serbia, J. Serb. Chemical Society. 75 (2010) 1701–1709.

[10] I.M. Moreno, D. González-Weller, V. Gutierrez, M. Marino, A.M. Cameán, A.G. González, A. Hardisson, Determination of Al, Ba, Ca, Cu, Fe, K, Mg, Mn, Na, Sr and Zn in red wine samples by inductively coupled plasma optical emission spectroscopy: evaluation of preliminary sample treatments, J. Microchem. 88 (2008) 56–61.

[11] K. Pyrzyńska, Chemical speciation and fractionation of metals in wine, J.Chem.Speciat. Bioavailab. 19 (2007) 1–8.

[12] The international organization of vine and wine, Resolutions of the OIV. http://www.oiv.int/public/medias/1567/oiv-oeno-478-2013-en.pdf, 2001 (accessed 3.04.2001).

[13] A. Frankowska, M. Frankowski, Determination of Metals and Metalloids in Wine Using Inductively Coupled Plasma Optical Emission Spectrometry and Mini-torch, J. Food Analytical Methods. 10 (2017) 180–190.

[14] A. Gonzálvez, S. Armenta, A. Pastor, M. De La Guardia, Searching the most appropriate sample pretreatment for the elemental analysis of wines by inductively coupled plasma-based techniques, J.Agric. Food Chem. 56 (2008) 4943–4954.

[15] I.M. Alkiş, S.Öz, A. Atakol, N. Yilmaz, R.E. Anli, O. Atakol, Investigation of heavy metal concentrations in some Turkish wines, J. Food Composition and Analysis. 33 (2014) 105–110.

[16] G. Thiel, K. Danzer, Direct analysis of mineral components in wine by inductively coupled plasma opticalemission spectrometry (ICP-OES), J. Fresenius of Analytical Chemistry. 357 (1997) 553–557.

[17] H. Yabuta, H. Miyahara, M. Watanabe, E. Hotta, A. Okino, Design and evaluation of dual inlet ICP torch for low gas consumption, J. Anal At Spectrom. 17 (2002) 1090–1095.

[18] M. Núñez, R.M. Peña, C. Herrero, S. García-Martín, Analysis of some metals in wine by means of capillary electrophoresi. Application to the differentiation of Ribeira Sacra Spanish red wine, J. Analysis. 28 (2000) 432–437.

[19] M. Ortega-Heras, M.L. González-Sanjosé, S. Beltrán, Metal content of Spanish red wines from certified denomination of origin, J. QuimicaAnalitica. 18 (1999) 127–131.

[20] İ.Şen, F. Tokatlı, Characterization and classification of Turkish wines based on elemental composition, J. American Journal of Enology and Viticulture. 65 (2014) 135–142.

[21] A. Bonici, E. Gal, C. Cimpoiu, C.I. Bunea, F.D. Bora, Multi-element composition of red and white wines from Bujoru, Smulti and Oancea wine center, Romania, J. StudiaUniversitatis Babes-BolyaiChemia. 4 (2018) 113-128.

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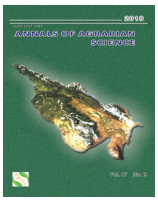

Evaluating consumer behavior for consumption of milk and cheese in Gjilan Region, Kosovo

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A B S T R A C T

The main objective of this paper was to evaluate consumers` consumption patterns of milk and cheese consumption in Gjilan Region of Kosovo by analyzing factors that influence purchasing decision for milk and cheese products.

In the model of the multiple linear function quantity of milk and cheese purchased by a household within a month is a function of family size (FS), a number of children aged 14 and younger (Ch), as well as the number of employed family members (EFM). The same model was used for the total expenditure for cheese. The results of the study revealed that family size; the number of employed people and the number of children in the household had a significant impact in determining the quantity of milk and cheese consumption. The results of the research are showing that as the size of a family and number of employed family member increase by one unit, in Gjilan Region, the quantity of milk consumed goes up by 10.622 liters/month. If others variables are held constant, the quantity of milk consumed is 7.74 liters/month. The results of research are showing that exists a positive relationship between the quantity of cheese consumed and other three variables (family size, number of children and number of employed family members).

Keywords: Consumption patterns, Milk, Cheese, linear model, Kosovo, Agricultural sector.

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Introduction

With all the efforts to improve the economic situation of the country, Kosovo still remains in the lower economic situation compared to other European countries [1]. Agriculture plays a significant role in the country's economy. The agricultural sector is accounted for 12.0% of GDP and is estimated to employ around 4.6% of total employees.

The food processing sector in Kosovo used to operate in traditional ways and managed by social enterprises, where nowadays they are no longer active. Consequently, modern private companies are emerging to operate in this dimension. Despite these efforts, large proportions of the companies are small and not in a position to meet the market demand which is much higher. It is understandable that there exists an important gap in the field. Investment in these companies and provision of innovative management techniques would help with the revitalization of the agro-processing industry in Kosovo. With several market interventions, Kosovo can easily access the international markets [2].

As in the study of Heiny et al. [3] who emphasize that with regard to livestock, cows, poultry and sheep have proven to be of greatest importance for the research region, the similar situation we can find in Kosovo's dairy sector which is relatively in a good development stage and one of the most promising sub-sectors with high potential for development of agricultural sector. Dairy cows occupy the biggest share regarding different categories within the structure of cattle, with 53% and are the major source of milk in Kosovo [4]. It has been noted that dairy farms contribute about €132 million to GDP, half the total value of the total agricultural production [5].

It should be emphasized that the economic changes occurring in the country significantly are expected to have an impact on the consumers'

buying behavior, attitudes, needs, and demand for milk and cheese in particular and dairy products in general. In addition to this, it is observed that an increasing number of foreign competitors coming into the scene of the country's market. These competitors are entering the domestic market with a variety of dairy commodities, market segmentation, and improved qualities. In Kosovo of the total supply, 80.9% was domestic production, and the rest is covered by imports [4]. Milk yields per cow are low compared to other European countries. In 2014, the estimated average milk yield per cow in Kosovo was 2,075 liters per year [6] while this average in EU-28 was 6,727 liters [7] situation stays better if we compare with findings of Heiny et al. [3] with 644L per year and from UNDP report 2011 for the Borjomi municipality 1500 L/year [8]

As Kapsdorferová and Nagyová (2005) [9] state that customers are the main drivers of profits and lever to increase business profitability. They significantly represent the ultimate component that deems due emphasis in the food chain.

This situation brings local dairy processors in disfavored position to become competitive in local and regional markets. On the other hand, Kosovo's market of the dairy industry is focusing on producing dairy commodities with lower costs and sufficient for domestic demand. Therefore, addressing this issue, studying the consumers' buying behavior, their preferences, attitudes, needs, and demand for dairy products is an important and critical point in improving the competitiveness and efficiency of the dairy in the country.

Nevertheless, there is limited information on consumers' buying behavior and demand for dairy products level in the dairy industry of Kosovo. Therefore, studies that focus on dairy consumption pattern are scanty [10]. In fact, the absence of information is an important problem in addition to other difficulties that are encountered by dairy sector in the country. There is no empirical study that shows the relationship between the buying behavior of consumers and demographic and socio-economic factors. Sridhar [11] stated that demographics have considerable influence on the consumer for every product. The goal of the demographic analysis is often to identify the demographic makeup of target market and find more market geographies with similar demographic characteristics. The changes in food consumption can be observed in the case of those products where the extent of price fluctuation was above the average Vasa [12]. The study by Marshall and Anderson [13] indicates that there is a trend of men going to shop, either as individuals or as members of a family or household unit. According to their study, this trend seems to go upward in the future. Hawkins et al., [14] stated that motivation is a perception representing an invisible inner force that triggers and compels a behavioral response and gives specific direction to that response. It is also stated by Solomon) [15] that motivation is processes that lead people to behave as they do.

Objectives and methods

The study area

Kosovo is divided into seven regions and 37 municipalities with 1,467 settlements [16]. Among the seven regions, this study is conducted in the Gjilan region. This region comprises eight municipalities namely: Shterpce, Novoberd, Gjilan, Kamenic, Viti, Ranillug, Partesh, Kllokot. The given region hosts 182,991 inhabitants [16].

Method description

In order to find out about the consumers' behavior, their attitudes, preferences, and demand for milk and cheese, a structured questionnaire with open-ended and close-ended questions was developed.

Data collection and processing

The data used in this study were obtained through an online survey with Kosovo`s consumers aged 18 years and older. In total 108 respondents participated in this survey. In order to avoid overestimation of the market demand for milk and cheese, even those households who happen to have their own cows were included in the data collection process. The survey was conducted during the period of February-March in 2014.

Data analysis

A multiple linear model was performed to find out the determinants of consumers' buying behavior, preferences, their attitudes toward the attributes of the quantity consumed and expenditures for milk and cheese products. Descriptive statistics were calculated for variables describing household characteristics and consumers` buying behavior.

Descriptive statistics of the household characteristics

The table below presents a summarized statistic of the household characteristics according to demographic and socioeconomic indicators. The average sample scores were summarized for the Gjilan Region. As shown below (Table 1), urban-rural typology is used to group respondents of the region the places of the respondents. It is indicated that higher proportion of the participants are from the rural area. Regarding gender issue, the proportion of male is nearly as triple as that of the female. This variation may be attributed to the fact that women are occupied with other works which hinder them from using the internet. The distribution of respondents across the age group of all five categories is not proportional.

The first two age groups take higher proportion in combination, while the other age groups are contributing with less proportion. In case of the educational level, the majority of the participants completed university level, while nearly quarter of the respondents completed high school. The proportion of respondents regarding employment seems to show less variation as it is shown in the other characteristics.

Descriptive statistics on consumers` buying behavior

Respondents were asked if they or their family members buy cheese and milk. The vast majority claimed that they or their family do buy the products while only fewer proportion responded otherwise. Among the two products, the percentage of respondents' interest towards cheese is higher than that of milk. Correspondingly, the percentage of people who responded "No" is higher for milk (Fig. 1).

It can be noted, therefore, that milk and cheese are consumed by the vast majority in the area. The difference in proportion between milk and cheese implies that there is a slight inclination of preference towards cheese than milk. According to Shavgulidze et al. [17] Cheese represents the main marketable commodity due to relative storability and high price; cheese is the most valuable item for an exchange.

With regard to the question of who makes a decision and buys the products among the family members, higher proportion claimed that both activities, buying and decision making, involve both husbands and wives. It is, as well, that children take part in decision making and buying by few proportion of respondents. Study results have shown that men

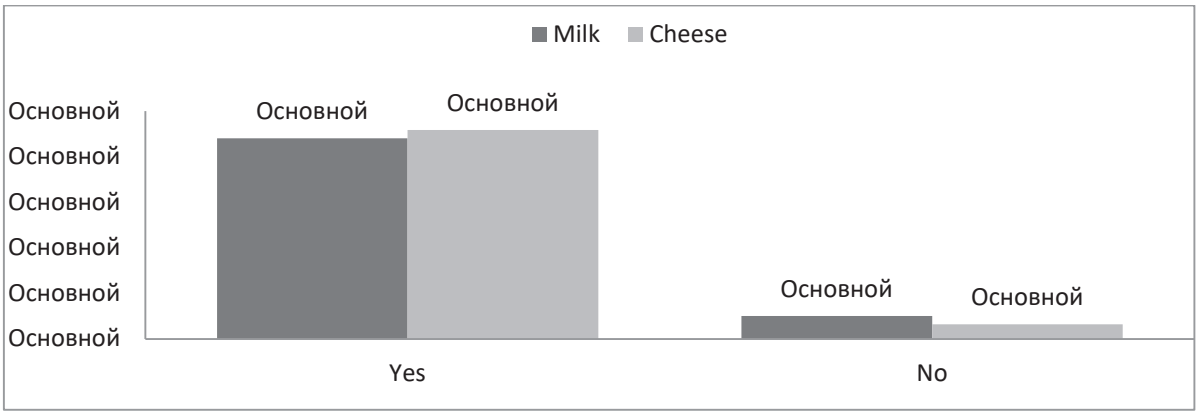
Table 1. *Characteristics of respondents*

Characteristics	Attribute	Percentage
Place	Rural	56.9
	Urban	43.1
Gender	Male	73.4
	Female	26.6
Age group	18-24	36.11
	25-34	37.04
	35-44	6.48
	45-54	12.96
	55+	7.41
Education level	Primary School	4.6
	High School	24.8
	University	70.6
Employment	Employed	43.1
	Unemployed	56.9

Source: Authors' calculation based on primary data, 2014

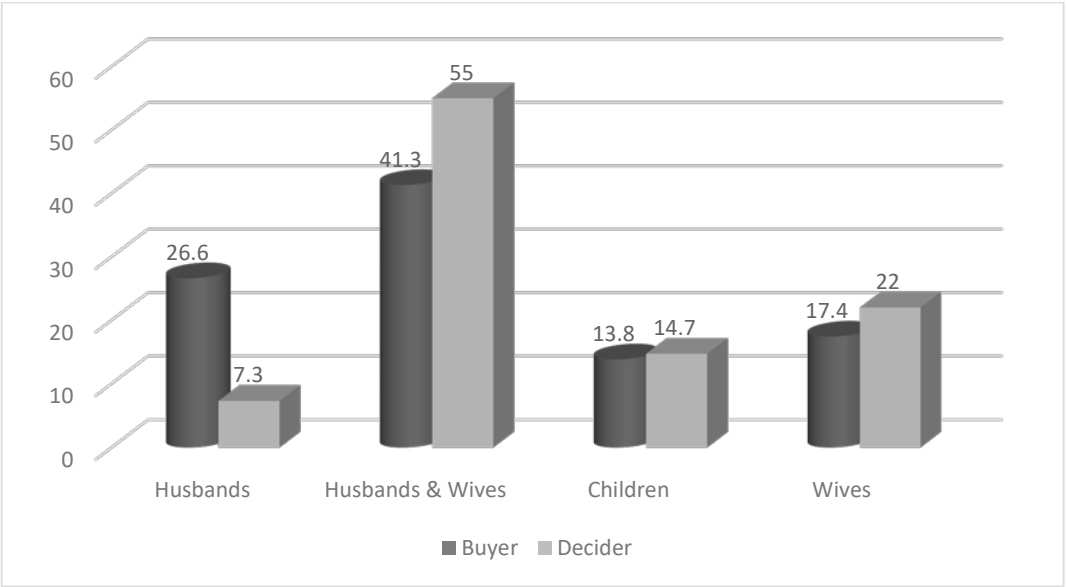
(husbands) alone barely participate in the decision making while it is indicated that they take part in buying activity (Fig. 2).

Therefore, there is the distinctive responsibility of buying and decision making within the family followed by expected variation among the families. However, buying and decision making among families is mainly done by the husbands and wives in general.



Source: Authors' calculation based on primary data, 2014

Fig. 1. *Respondents' response to buying cheese and milk*



Source: Authors' calculation based on primary data, 2014
Fig. 2. *Buying and decision making*

Source: Authors' calculation based on primary data, 2014

Fig. 2. *Buying and decision making*

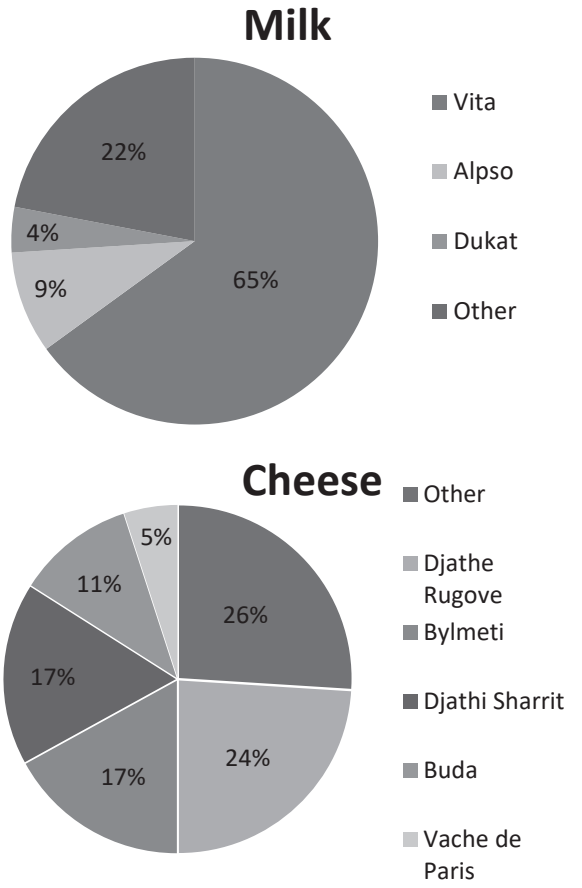
Consumers` preferences

Participants of the survey were asked about the most preferred milk and cheese brand that they buy. The proportion of preference for both products is quite varying. In the case of milk three brands and "other" was provided for respondents to select from. The higher percentage of respondents preferred 'Vita' which is domestic product while 22% selected "other" option. Only less proportion of respondents preferred other brands mentioned by name. These products are in fact not produced domestically. In regard to the preference for cheese, five brands and "other" option were given to respondents to choose from. The preference of respondents seems to be distributed across these brands. No preference with significantly higher proportion is indicated. However, higher percentage compared to other responses went to "other" option. It is important to note that very small proportion of respondents chose Vache de Paris which is basically an imported cheese product. The three domestic products namely: Djathe Rugove, Djathi Sharrit, and Bylmeti, are domestic products chosen by a higher proportion of respondents all combined (Fig. 3).

It is possible to note that domestic milk product is of higher preference implying that there is a possibility of the product to remain more competent and hold significant market share. In the case of cheese, the domestic products seem to have their own share which is higher than other when combined. It is noted from the respondents' choice of "others" that there are other brands that are preferred to the ones listed in the survey. These products might include those obtained directly from the farmers.

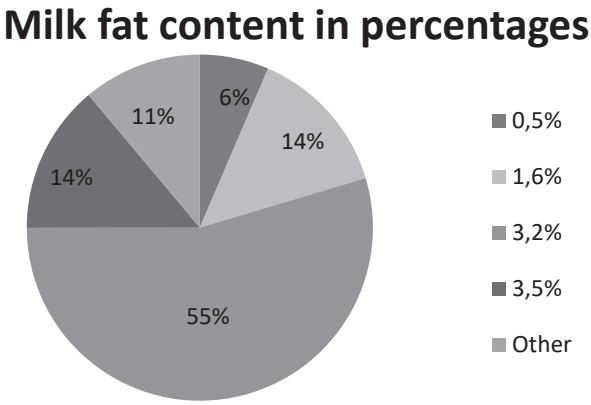
Regarding the preference related to the percentage of fat content in milk product (Fig. 4), a higher proportion of participants preferred a milk product with a fat content of 3.2%. An equal proportion of the respondents preferred a milk product with 1.6% and 3.5% fat content, while very small proportion chose 0.5%. The preference in view of fat content appears to indicate that moderately higher fat content is a higher choice that milk products with lower fat content.

A Higher proportion (Fig. 5) of the participants showed a preference for the type of cheese described as "white strong" followed by "white soft". Only small proportion of respondents is interested in Edam cheese. It is important to note that nearly 1/5 of the respondents showed preference of light cheese with less fat.



Source: Authors' calculation based on primary data, 2014

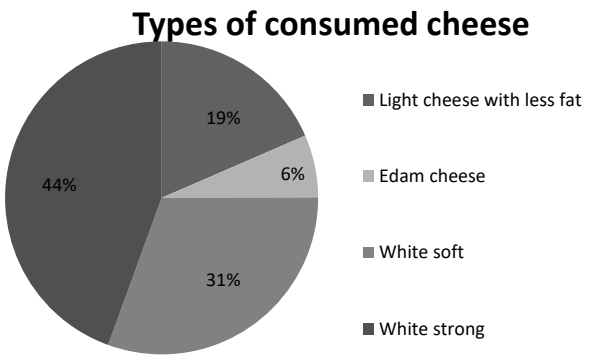
Fig.3. *Brand Preference of milk and cheese*



Source: Authors' calculation based on primary data, 2014

Fig. 4. *Preference related to percentage of fat content in milk*

A Higher proportion (Fig. 5) of the participants showed a preference for the type of cheese described as "white strong" followed by "white soft". Only small proportion of respondents is interested in Edam cheese. It is important to note that nearly 1/5 of the respondents showed preference of light cheese with less fat.

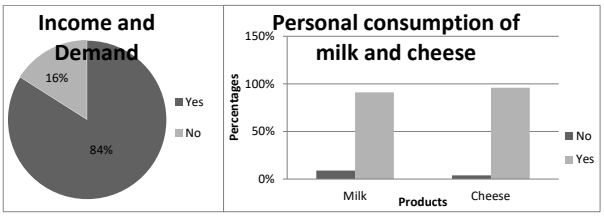


Source: Authors' calculation based on primary data, 2014

Fig. 5. *Type of cheese preferred by respondents*

Demand, income, and personal consumption

For an inquiry provided to respondents whether they fulfill the demand for milk and cheese with monthly income available, the higher majority claimed that they do. Only less than quarter proportion are in a position not to fulfill their demand with their earnings (Fig. 6, left).



Source: Authors' calculation based on primary data, 2014

Fig. 6. *Income and demand for milk*

This implies that majority of the people in the study region can afford the prices of the products. On the other hand, respondents were asked if they personally consume milk and cheese. Vast majority replied that they personally consume both products with slightly higher percentage of cheese (Figure 6, right). This finding coincides with the demand and monthly income balance indicated with the pie chart on the left. Very small proportion of respondents does not consume both products.

Multiple Regressions linear

The estimated average quantity of milk consumed in liters/month in the FSi was:

Q: Milk (l/month) = 7.74 + (0.912 FS) - (0.09 Ch) + (2.06 EFM) [R^2=0.393] (1)

The regression result shows that the values of t-statistics are 2.38, 1.38, -0.087 and 1.889 for the constant, family size (p=0.037), number of children (p=0.04) and number of employed family member (p=0.02) respectively. The estimated coefficients in the equation (1) indicated that there was a positive relationship between the quantity of milk consumed in the FSi and number of employed family member and the family size, whereas there is a negative relationship with a number of children. The estimates show that these variables determine and significantly explains the variation of the milk consumption at the household level. As the size of a family and number of employed family member increase by one unit, quantity consumed goes up by 10.622 liters/month. If others variables are held constant, the quantity consumed is 7.74 liters/month.

The estimated average quantity of cheese consumed in kilograms/month in the FSi was:

Q: Cheese (kg/month) = 5.37 + (0.163 FS) + (0.033 Ch) + (0.313 EFM) [R2=0.19] (2)

The regression result shows that the values of t-statistics are 2.891, 0.431, 0.055 and 0.503 for the constant, family size (p=0.03), number of children (p=0.043) and number of employed family member (p=0.026) respectively. From the coefficients of the equation (2), it is possible to note that there exists a positive relationship between the quantity of cheese consumed and the other three variables (family size, number of children and number of the employed family member). One unit increase of these variables would yield 5.879 kilograms/month.

The estimated average expenditure of milk consumed in liters/month in the FSi was:

E: Milk (l/month) = 8.57 + (0.331 FS) + (1.38 Ch) + (2.36 EFM) [R2=0.499] (3)

From equation (3), it can be seen that the values of t-statistics are 2.516, 0.478, 1.246 and 2.069 for the constant, family size (p=0.46), number of children (p=0.04) and number of employed family member (p=0.031) respectively. The fact that the coefficients of family size, number of children and number of the employed family member are all positive indicates that there is a positive relationship between the average expenditure of milk consumed and the variables. The model further depicts that 12.64 liters/month is consumed as a result of one unit of increase of the three variables.

The estimated average expenditure of cheese consumed in kilograms/month in the FSi was:

E: Cheese (kg/month) = 13.0 + (0.321 FS) + (0.89 Ch) + (0.26 EFM) [R2=0.25] (4)

The regression result shows that the values of t-statistics are 4.155, 0.503, 0.925 and 0.230 for the constant, family size (p=0.04), number of children (p=0.03) and number of employed family mem-

ber (p=0.049) respectively. From the coefficients of equation (4), it is noted that there exists a positive relationship between the average expenditure of cheese consumed and the family size, number of children and number of employed family member. Consequently, an amount of 14.46 kilograms/month is consumed as a result of a one-unit increase in other variables.

Conclusion

From the two dairy products analyzed, cheese is preferred by a wider spectrum of people than milk. Since the decision making and buying are done by both the wife and husband, it can be concluded that there is no gender issue problem regarding the examined topic in the area. From the result, it is also possible to conclude that, from different brands of milk; 'Vita' is the most preferred brand by the consumers. In addition, since Vita is a domestic product, it can be concluded that the consumers are proud of using the domestic product. Regarding the brands of cheese, though the preference looks the same for most of the brands, it can be concluded that 'Vache de Paris' is the least preferred product. Since the most preferred milk is the domestic one and the least preferred cheese is the imported one, it can be concluded that domestic products are more preferred than imported ones. On the other side, it shows that the domestic products are competent enough with the imported ones. Regarding fat content, it can be concluded that the milk that contains the lowest fat is the less preferred one. As far as the type of cheese is concerned, it can be concluded that the 'white strong' is the most preferred cheese type from the rest of the cheeses.

Since there is a positive relationship between the quantity of milk consumed in the family size and number of employed family member, it can conclude that when the employed member of the family increases, the amount of milk consumed would also increase. This also shows that people have a high demand for food consumption; means the income elasticity for milk is high. In the case cheese, there exists a positive relationship between the quantity of cheese consumed and the other three variables. It is also found out that the relationship between expenditure and other variables in both milk and cheese is positive.

References

[1] World Bank, The World Bank group in Kosovo, Country snapshot. World Bank Publications, 2014

[2] Ministry of European Integration of the Republic of Kosovo, Kosovo`s economy, 2012 Retrieved from: http://www.mei-ks.net/?page=2,236,518

[3] Heiny, J., Mamniashvili, G., & Leonhaeuser, I. U. The socioeconomic situation of private households in the Kazbegi region–First insights based on quantitative data, J. Annals of Agrarian Science, Vol. 15 No.1 (2017) 31-39.

[4] MAFRD, Ministry of Agriculture, Forestry and Rural Development. *Green Report.* Prishtine: Ministry of Agriculture, Forestry and Rural Development, 2016.

[5] EYE, Study report for the main agribusiness subsectors in Kosovo Prishtine: Recura, 2014.

[6] Mafrd, Ministry of Agriculture, Forestry and Rural Development. Green Report 2015. Prepared by the Department of Economic Analysis and Agricultural Statistics (DEAAS), 2015. Available at ttp://www.mbpzhrks.net/repository/docs/Raporti_i_Gjelber_2015_final.pdf Accessed 20 Jun 2016.

[7] European Commission, Short-Term Outlook for EU arable crops, dairy and meat markets in 2015 and 2016; 2015, Available at http://ec.europa.eu/agriculture/markets-andprices/short-term-outlook/pdf/2015-11_en.pdf Accessed 10 May 2016

[8] Ecovision – Union for Sustainable Development Socio-economic and livelihood assessment report for consultancy services for rapid rural assessment and local livelihood opportunities Ecovision – Union for Sustainable Development (Ed.), For UNDP Project: Restoration of Forest Ecosystems Damaged in Armed Conflict in Georgia Tbilisi, 2011.

[9] Z.Kapsdorferová. and L. Nagyová, Consumer behavior at the Slovak dairy market. Nitra, Slovak Republic, Slovak University of Agriculture, Agric. Econ. – Czech, 51, (8), 2005 pp. 362-368.

[10] Nushi M. and F. Selimi , An Assessment of the Competitiveness of the Dairy Food Chain in Kosovo, In: "Study 1. AgriPolicy Enlargement Network for Agripolicy Analysis", Kosovo, 2009, pp. 125-170

[11] Sridhar G., Consumer Involvement in Product Choice - A Demographic Analysis. Vitakshan.

XIMB J. of Management (2007) 131-148.
[12] Vasa L., Economic Coherences Between Food Consumption and Income Conditions in the Hungarian Households. J. Annals of Agrarian Sciences Vol. 12, No.3 (2014) 228-233.
[13] Marshall D.W. & Anderson A.S., Who's responsible for the food shopping, a study of young Scottish couples in their honeymoon period. International Review of Retail, Distribution and Consumer Research 10 (1) (2000) 59–72.
[14] Hawkins D. L., D. Mothersbaugh and J. R. Best, Consumer Behavior: Building Marketing Strategy, McGraw-Hill, New York, 2007.
[15] Solomon M.R., Consumer Behavior, 10th Edition. Prentice Hall PTR, 2011.
[16] Kosovo Agency of Statistics, Estimation Kosovo Population, 2012. Pristina, 2013.
[17] Shavgulidze R., Bedoshvili D., & Aurbacher J. (2017). Technical efficiency of potato and dairy farming in mountainous Kazbegi district, Georgia, J. Annals of Agrarian Science, Vol.15, No 1 (2017) 55-60.

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