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Implications of soil pollution with heavy metals for public health

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Soil of military grounds is often polluted with heavy metals. Their concentrations may be dosens of times higher in polluted regions. The affected soils are permeable, so the pollutions can get into water and spread to the environment. Into human and animal organisms they can get with food and water. Heavy metals are very dangerous for people's health, and we must know their accumulation places, intensity of scatter and integral risk for health. The purpose of this work was to establish links between zones polluted with heavy metals and morbidity caused by pollution with heavy metals. The morbidity caused by heavy metals (Pb, Cu, Zn, Ca and other) in the polluted regions is 1.4–1.5 times higher for adults and teenagers and 1.5–3.9 times higher for children aged under 14 years than the mean morbidity of the same diseases in Lithuania. Hypothetically, it is possible to prognosticate that this problem will grow in future because the ratio of the newly registered and the existing cases of morbidity for children aged under 14 years is 1.3–1.5 times higher than for adults.

Key words: soil, military activities, heavy metals, public health

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INTRODUCTION

The upper layer of the ground is very friable, fertile, and composed of a complex of organic and mineral compounds. It is of great significance for people's life and health.

Man's agricultural or other activities can basically modify the stratum of the upper ground. This means that people's life and health become at risk. Recently this phenomenon (process) has become not only local, but also global, and this may cause irreversible changes of natural structure. To avoid the most severe negative results, in 1987 the World Commission on Environment Development (WCED) of the United Nations (UN) accepted the conception of sustainable development, which anticipates the optimal ratio between using environmental resources and the development of industry. As the environment and the development of industry are directly related with the quality of public health, in 2002 the World Health Organization (WHO) accepted the conception of sustainable development on the basis of social health development (WHO, 2002; Public Health, 2002; Geiss, Wortmann, 2003; Ritt, 2003). Its main element is to keep a balance between the domains of social, economic, ecological life and health, to ensure the quality of life.

Some factors of the ecological or geological nature can cause a great risk, especially for public health. In health researches it has been established that of especial danger for health is soil which accumulates heavy metals. It has been proven that high concentrations of these metals in the soil can be the factors of people's death or poisoning (Ašmenskas, Baubinas, Obelenis, 1997). Heavy metals from soil with water (also in vegetables) get into human organisms, poisoning and destroying them. Most of heavy metals (like mercury (Hg), plumbum (Pb), cadmium (Cd), chrome (Cr), copper (Cu), nickel (Ni), zinc (Zn), cobalt (Co), vanadium (V), molybdenum (Mo), beryllium (Be), uranium (U), strontium (Sr), arsenic and other) have shown all or at least several negative effects on health. Their effect may be carcinogenic, mutagenic, teratogenic, neurotoxical. The most dangerous and synergetic are the effects when the damage is realized by separate concentrations not exceeding the standard level (Taraškevičius, Radzevičius, 1999). It is rather difficult to evaluate the synergistic effect of heavy metals because they can accumulate and their effect may be latent.

The target of this work was accumulation of heavy metals in the former military grounds and their possible effect on morbidity.

As the effect of heavy metals is latent or synergistic, to identify it is practically impossible, therefore we used a systemic approach (Jurgelėnas, Juozulynas, Norvaišas, Šiurkienė, 2004). Its essence is that the levels of heavy metals and the state of human health are regarded not as a cause and effect, but as a constant biochemical process when heavy metals present in the soil as a hazardous factor of health constantly affect the health quality of some sectors of society. Hypothetically, in the areas where the concentrations of heavy metals are high the risk must be also high.

SCATTER OF SOIL CONTAMINATION WITH HEAVY METALS

In general, in Lithuania soil pollution with heavy metals is not high, but soil is a place from which food, plants, animals and people may be polluted. The pollution with Pb in various regions on average varies from 10.9 to 14.1 mg/kg, with Cu within 5.0 to 7.0 mg/kg, Zn 23.5–37.2 mg/kg, Cd 0.48–0.63 mg/kg, Ni 7.4–10.9 mg/kg (Ašmenskas, Baubinas, Obelenis, 1997). Heavy metals are durable contaminants. Most of organic contaminants disintegrate in nature, but the natural environment cannot decompose or destroy heavy metals. They may be only weakened or integrated into temporary relatively innocuous complexes. After disintegration of these complexes heavy metals easily get into clay and other soil layers and also may get into plants, animals, food and water or directly into a human body. Studies of heavy metals in the Nemunas polder grasslands have shown that water meadow soils contained 1.5 times more heavy metals than in land meadow soils. Also, there was 2.5 times more heavy metals in old ploughed lands (Vasiliūnas, Gipiškis, 1995). Heavy metals from soil get into alimentary products. Researches by Valiukėnaitė and co-authors into the pervasion of heavy metals in cow's milk has shown that in many cases the content of Pb exceeded the permissible levels (Valiukaitė, Jarmalaitė, Stankevičienė, 2005). Heavy metals penetrate even into ecological agriculture. Researches made by Rutkovienė and Karnauskas (1998) have shown that low levels of Pb were present only in ecological suga-beets and in the one of the barley samples. The concentration of heavy metals in alimentary products did not exceed the maximum permissible level (MPL). Pb is mostly accumulated in pig liver, chicken meat, eggs, and barley grain. In 2003, researches in fish showed that in most Lithuanian rivers and lakes the content of heavy metals (Cu, Zn, Cd, Cr, Ni, and Hg) in fish muscles doesn't exceed the MPL, but in fry tissues their levels exceeded the data of previous years, although only Pb exceeded the BLC. In 2003, the content of heavy metals in Lake Drūkšiai bottom sediments was 7 to 15 times higher than in previous years and higher than in the other lakes (Sakalauskienė, Štriupkuvienė, 2004). Wild herbivorous animals hunted for food (roe, red deer, north deer, moose, boar) are good bioindicators showing environmental pollution with harmful substances. To identify harmful substances such as heavy metals or pesticides in the wild animals' tissues are important to ensure that their levels in foodstuff do not exceed the limits which are safe for man. According to data of Malakauskas, Januškevičienė, Vaitkus (2004), in some samples heavy metals exceeded the permissible hygienic norms but were not hazardous for health, because these products are very rarely used.

Fig. 1. Location of the Gaižiūnai Military Ground (Greičiūtė, Juozulynas, Šurkienė, Valeikienė, 2007)

1 pav. Gaižiūnų karinio poligono geografinė padėtis (Greičiūtė, Juozulynas, Šurkienė, Valeikienė, 2007)

These examples show that the distribution of different heavy metals in the environment although not exceeding the MPL, are hazardous because of their synergetic effects whose integral norms are just unknown. Especially dangerous are accumulation foci epicentres of heavy metals. It has been long ago noticed that in different regions soils may contain different levels of chemical substances. They are predetermined by the biochemical processes. Zones containing too much of different chemical elements may be of various size from local to regional and even global. For example, the zone of Pb distribution from the epicentre may reach 100 kilometres.

Such zones arise from unbalanced or specific activities. In Lithuania, they hypothetically could be the former military grounds (Fig. 1).

Military grounds are territories of a specific purpose, in which various buildings necessary for exercises are often constructed for shooting and explosure practical training. For these reasons, the soil in military grounds is often polluted with heavy metals because of continuous damage. There, vegetation is very soarce in some spots of land and even missing, and sandy wastelands are formed. There are a lot of military ground territories where the vegetation cover is completely destroyed. More affected soil is more permeable, so pollution can easily get into groundwater. The present study has shown that the content of organic matter in soil of some territories used for army needs is significantly (by 66% to 99%) lower than in the undamaged territories. Soil pollution with heavy metals depends on the type of territory and on its use intensity; most polluted with Pb and Cu are soils in shooting ranges, meanwhile territories used for military transport are most heavily polluted with metals contained in oil (Cr, Pb, Mn, etc.). Besides, most of the environment is polluted with oil products; in the fields of tactical trainings lie bullets and explosive warhead residues, and because of regular damages sandy soil prevails. Military activities cause damage to the environment because of soil pollution with various chemical substances, also in the surrounding territories. Soil pollution is indicative also of the risk of groundwater pollution (Vasarevičius, Greičiūtė, 2004) (Fig. 2.)

EFFECT OF HEAVY METALS ON HUMAN HEALTH

Researches of health and safety have shown that heavy metals are much more dangerous than it was considered before. Their small doses accumulate in the body and then latently destroy it.

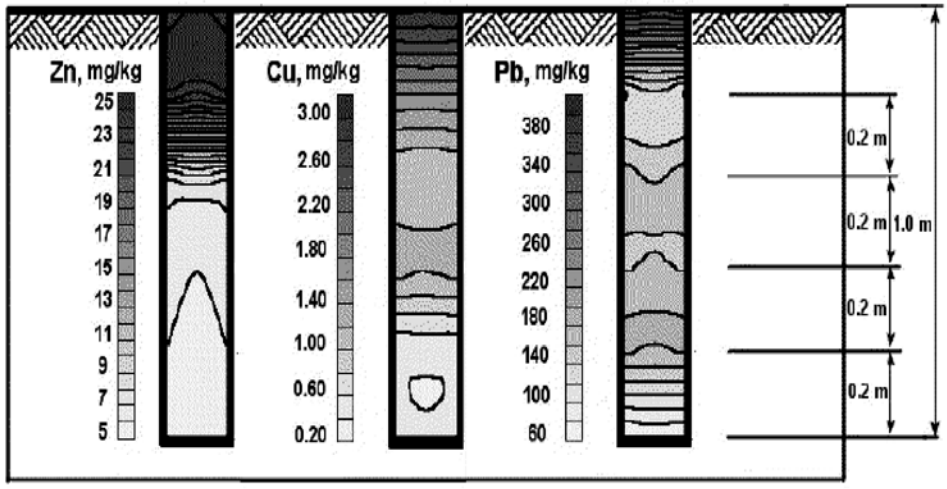

Fig. 2. Concentrations of heavy metals in the territory of abandoned military settlement in Gaižiūnai Military Ground (depth varies from 0 to 1 m) (Greičiūtė, Juozulynas, Šurkienė, Valeikienė, 2007)
2 pav. Sunkiųjų metalų pasiskirstymas apleisto karinio miestelio teritorijoje Gaižiūnuose (iki metro gylyje) (Greičiūtė, Juozulynas, Šurkienė, Valeikienė, 2007)

Table. **Diseases registered in out-patient health care institutions, 2005**
Lentelė. **Gyventojų ligos, užregistruotos ambulatorinę pagalbą teikiančiose asmens sveikatos priežiūros įstaigose 2005 m.**

Diseases		Population	Lithuania	Pabradė		Kaunas district		Klaipėda district	
				Morbidity	K*	Morbidity	K*	Morbidity	K*
Tumours	**Morbidity	Adults and teenagers	30.0	54.7	0.8	25.7	0.8	27.3	0.9
		Children till 14 years old	3.0	6.2	2.1	3.4	1.1	2.6	0.8
	**New cases	Adults and teenagers	9.1	14.6	1.6	12.4	1.4	9.3	1.0
		Children till 14 years old	1.3	5.1	3.9	2.1	1.6	2.0	1.5
	Ratio of new cases and morbidity %	Among	30.3	26.6		48.2		34.1	
		Among	43.4	82.2		61.7		76.9	
Diseases of blood and blood production organs	** Morbidity	Adults and teenagers /	3.1	4.9	1.5	4.2	1.3	6.5	2.1
		Children under 14 years	13.1	17.8	1.3	8.9	0.6	28.8	2.2
	** New cases	Adults and teenagers	1.2	2.3	1.9	2.7	2.2	3.8	3.1
		Children under 14 years	7.8	11.0	1.4	6.5	0.8	23.9	3.0
	Ratio of new cases and morbidity %	Among	38.7	4.9		64.2		58.4	
		Among	59.5	61.8		73.1		82.9	
Nervous system diseases	** Morbidity	Adults and teenagers	41.0	32.6	0.7	135.5	3.3	56.5	1.3
		Children under 14 years	21.1	29.3	1.4	25.2	1.1	25.2	1.1
	** New cases	Adults and teenagers	15.9	9.8	0,6	72.1	4.5	29.9	1.9
		Children under 14 years old	1.9	17.7	1.6	12.7	1.1	14.7	1.3
	Ratio of new cases and morbidity %	Among	38.7	30.1		53.2		52.9	
		Among	51.6	60.4		50.4		58.3	
Congenital defects and anomalies	** Morbidity	Adults and teenagers	1.5	3.3	2.2	3.5	2.3	2.7	1.8
		Children under 14 years	24.5	18.8	0.7	2.0	1.1	74.1	3.0
	* New cases /	Adults and teenagers	0.5	1.1	2.2	1.2	2.4	0.4	0.8
		Children under 14 years	11.3	9.0	0.8	10.2	0.6	21.4	1.9
	Ratio of new cases and morbidity %	Among	33.3	33.3		34.2		14.8	
		Among	46.1	47.8		36.4		28.8	
Abnormal clinical and laboratory findings	** Morbidity	Adults and teenagers	5.0	18.8	3.8	15.2	3.0	21.9	4.4
		Children under 14 years	52.4	52.3	0.9	117.9	2.2	211.4	4.1
	** New cases	Adults and teenagers	3.8	9.0	2.3	11.1	2.9	15.2	4.0
		Children under 14 years old	35.9	20.0	0.5	77.4	2.1	133.4	3.8
	Ratio of new cases and morbidity %	Among	76.0	47.8		73.0		69.4	
		Among	68.5	38.2		65.6		62.9	

* Local morbidity ratio with average morbidity in Lithuania
** Morbidity and new cases of adult, teenagers, and children under 14 years per 1000
Source: Lithuanian Health Information Centre 2005

* K vietovės sergamumo santykis su Lietuvos sergamumo vidurkiu
** Sergamumas ir nauji atvejai 1000-iui suaugusiųjų ir paauglių bei vaikų iki 14 metų
Šaltinis: Lietuos sveikatos informacijos centras, 2005 m.

In humans and animals, they affect the central (CNS) and peripheral nervous systems (PNS), the functioning of blood production system and internal endocrine glands gets impaired. Especially dangerous is Pb which strongly affects the nervous system and other vitally important functions. Accumulation of heavy metals is mostly displayed in carcinogenic, mutagenic and embryotoxic effects on the organism. The negative effect of heavy metals is frequently invisible because some of changes in the organism manifest only after some or several decades or years and sometimes even only in the next generations. A study into environmental pollution with Pb and the occurrence of myocardial infarct (MI) morbidity (Dulskienė, 2003) has revealed that air pollution with heavy metals exceeding 0.225 μg/m^3 tended to increase by 12% the risk of the first MI in men aged 24–64 years. The MI morbidity of younger men of employable age was by 7.8% and of those elder by 16% higher in the zones of low Pb pollution. Cr can cause cancerous diseases of the pulmonary and digestive systems; Cu can cause pulmonary, hepatic, digestive and other disorders. Especially difficult is the prognosis of the diseases induced by the joint effect of several heavy metals. In such cases we deal with an integral factor of health risk which affects the common state of health or first of all damages its weakest points. Therefore, it is very important to know heavy metal accumulation places and to organise respective health services. Territories of military grounds are polluted not only with one, but with several metals; especially dangerous are Pb, Zn, Cu and other. These elements induce the development of diseases such as tumours, hemopoietic and cardiovascular systems, nervous system, congenital defects, anomaly of chromosomes and other clinical and genetic derangements.

Table shows the possible morbidity in the biogeochemical zones in whose epicentre there are military grounds, which a supposed influence of heavy metals.

These data are not strongly determined because such an experiment is impossible. Morbidity may be affected not only by heavy metals, but also by other factors, among them the quality of health services. Our purpose was to compare morbidity values in polluted regions with the respective average values for Lithuanian in order to reveal the respective effects of heavy metals.

Our data shows that morbidity of the regions containing a biochemical focus in their epicentre is higher than the analogous average morbidity in Lithuania. Tumorous diseases in adults and teenagers are 1.8 times more frequent in the Pabradė region than the average morbidity of these diseases in Lithuania. Morbidity of blood and hemopoietic diseases here is 1.5 times higher, in Kaunas region 1.3 times, and in Klaipėda region 2.1 times higher than the Lithuanian average. Diseases of the nervous system in Kaunas region are approximately 3.3 times and in Klaipėda region 1.3 times more frequent than the Lithuanian average.

Tumour morbidity in the biochemically exposed regions among children aged under 14 years gives rise to anxiety. In the study regions, it is higher (1.5 to 3.9 times) than the Lithuanian average: blood and blood system – 1.3 to 2.2 times, diseases of nervous system – 1.1 to 1.4 times.

The rate of newly registered cases among adults and teenagers is higher than the Lithuanian average (1.4 to 4.5 times), and among children aged under 14 years ranges from 1.3 to 4.1 times for separate diseases. Newly registered cases of tumourous diseases in the region of Pabradė are 3.9 times, in the region of Kaunas 1.6 times and of Klaipėda 1.5 times more numerous. The situation is similar with the hemopoietic and nervous system diseases. These data show tha the territories of the former military grounds are the epicentres of an increased risk for health.

The data of Table let are indicative of possible morbidity tendencies. To this end, we have introduced the index of new cases and morbidity rate ratio. It does not strongly define the process, but it may indicate its possible direction. This index of all diseases associated with heavy metals is higher 1.3 to 1.5 times in children aged under 14 years than in adults and teenagers of Lithuania. We believe that this is a dangerous tendency because the growing morbidity of the next generations is already programmed now. But in zones of biochemical effect this ratio is even higher than the Lithuanian average. In the region of Pabradė, for the cases of tumours it is 82.2%, in the region of Kaunas 61.7%, in the region of Klaipėda 76.9% versus the Lithuanian average of 43.4%. The situation of morbidity with other diseases, except abnormal clinical and laboratory findings, is similar. These data allow a hypothetic assumption that pollution with heavy metals means an integral risk for health, which increases the intensity of common morbidity, although the spread of separate metals doesn't exceed the permissible levels.

CONCLUSIONS

1. In the territories of the former military grounds soil, soil pollutions with heavy metals generates the epicentres of an integral biochemical effect. Although the levels of separate metals do not exceed the permissible standards, their joint effect generates a zone of the integral biochemical effect in which Pb prevails in the biogenic matrix and the soil.
2. Territories of military grounds as epicentres of the biochemical effect on public health in the surrounding regions induce diseases cause by heavy metals, such as derangements of blood or the hemopoietic system, nervous system, etc. They are especially dangerous to children. The frequency of these disease in such regions is higher than the average morbidity in Lithuania. This morbidity in future is likely to be growing because the newly registered cases and the extent of the problem are higher among children aged under 14 years than among adults.

References

1. Ašmenskas J., Baubinas A., Obelenis V. 1997. Aplinkos medicina. Vilnius. 105 p.
2. Dulskienė V. 2000. Aplinkos oro užterštumas švinu ir sergamumas miokardo infarktu. *MEDICINA*. ***39***(*9*).
3. Geiss J., Wortmann D. 2003. Nachhaltige Entwicklung – Strategie fur das 21. Jahfhundert? Eine interdisziplinare Annaherung. Leske + Budrich Opladen.
4. Greičiūtė K., Juozulynas A., Šurkienė G., Valeikienė V. 2007. Research on soil disturbance and pollution with heavy metals in military grounds. *Geologija*. ***57***. 14–20. http://www.arbeiterkammer.at/pictures/importiert/Tagungsband_149.pdf
5. Jurgelėnas A., Juozulynas A., Norvaišas S., Šurkienė G. 2004. Visuomenės sveikatos plėtros integruotas tyrimas. *Sveikatos mokslai*. ***3***(*34*). 21–24.
6. Lietuvos Sveikatos Informacijos Centras. http://www.lsic.lt/
7. Malakauskas M., Januškevičienė G., Vaitkus J. 2003. Sunkiųjų metalų (Pb, Cd ir Hg) kiekis sumedžiotų laukinių žvėrių raumenyse ir vidaus organuose. *Veterinarija ir zootechnika*. ***24***(*46*).
8. Public Health. http://ec.europa.eu/health/ph_projects/2003/action2/action2_2003_05_en.htm
9. Ritt T. 2003. Soziale Nachhaltigkeit: Von der Umweltpolitik zur Nachhaltigkeit.
10. Rutkovienė V., Kranauskas A. 1998. Ekologiškų ir įprastinių maisto produktų kokybės tyrimai. http://www.ku.lt/svmf/sveiki/EkokTyr.htm
11. Sakalauskienė G., Štriupkuvienė N. 2004. Sunkiųjų metalų kaupimasis žuvyse ir dugno nuosėdose. http://aaa.am.lt/VI/article.php3?article_id=1203
12. Taraškevičius R., Radzevičius A. 1999. Sunkiųjų metalų žemėlapiai miestų savivaldybėse. http://ausis.gf.vu.lt/mg/nr/98/9/9sunkm.html
13. Valiukėnaitė R., Jarmalaitė I., Stankevičienė M., Stankevičius H. 2005. Palyginamoji sunkiųjų metalų karvių piene apžvalga. *Veterinarija ir zootechnika*. ***29***(*51*). 55.
14. Vasarevičius S., Greičiūtė K. 2004. Gruntų taršos sunkiaisiais metalais tyrimas Lietuvos kariniuose poligonuose. *Journal of environmental engineering and landscape management*. ***XII***(*4*).
15. Vasiliūnas L., Gipiškis V. 1995. Sunkieji metalai Nemuno žemaslėnio polderių pievose ir žemės ūkio produktuose. http://www.geo.lt/metrastis/29/PDF/36-40.pdf
16. WHO in Johannesburg 2002. http://www.who.int/media-centre/events/johannesburg/en/index2.html

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DIRVOŽEMIO UŽTERŠTUMAS SUNKIAISIAIS METALAIS IR ŽMONIŲ SVEIKATA

Santrauka

Karinių poligonų dirvožemis dažnai būna užterštas sunkiaisiais metalais, kurių koncentracija gali būti kelis ar keliasdešimt kartų didesnė negu neužterštų regionų. Pažeistas dirvožemis yra pralaidesnis, todėl teršalai patenka į vandenis ir išplinta aplinkoje, o su augaliniu maistu ir vandeniu pakliūva ir į gyvulių bei žmonių organizmus. Sunkieji metalai yra labai pavojingi žmonių sveikatai, todėl reikia žinoti jų susikaupimo vietas, sklaidos intensyvumą ir riziką sveikatai. Šio darbo tikslas – išsiaiškinti taršos sunkiaisiais metalais poligonų zonose ir sergamumo, kurį galėjo sukelti minėta tarša, sąsajas. Tyrimu nustatyta, kad sergamumas sunkiųjų metalų sukeltomis ligomis užterštuose regionuose suaugusiųjų ir paauglių yra 1,4–4,5 karto, o vaikų iki 14 metų – 1,5–3,9 karto didesnis už vidutinį sergamumą tomis ligomis Lietuvoje. Taigi galima teigti, kad ateityje šis sergamumas didės, nes naujai užregistruotų ir žinomų ligų atvejų santykis vaikams iki 14 metų yra 1,3–1,5 karto didesnis negu suaugusiesiems ir paaugliams.

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ЗАГРЯЗНЕНИЕ ПОЧВЫ ТЯЖЕЛЫМИ МЕТАЛЛАМИ И ЗДОРОВЬЕ НАСЕЛЕНИЯ

Резюме

Почва военных полигонов часто загрязнена тяжелыми металлами. Их концентрация может превышать в несколько десятков раз естественную норму. Поврежденная почва полигонов становится проницаемой, и загрязняющие вещества легко попадают в грунтовые воды и вместе с ними – в пищу. Тяжелые металлы очень вредны для здоровья, поэтому необходимо знать места их скопления, чтобы предпринять меры предосторожности. Цель данной работы – оценить связь между загрязнением почвы тяжелыми металлами в зоне бывших военных полигонов Литвы и болезнями населения в этих регионах, в результате долгосрочного воздействия тяжелых металлов. Результаты исследования показали, что заболеваемость под с воздействием тяжелых металлов (Pb, Cu, Zn, Cr, и др.) у взрослых и подростков в 1,4–4,5 раза, а у детей до 14 лет – в 1,5–3,9 раза выше, чем средняя заболеваемость по Литве теми же болезнями. Гипотетически можно предположить, что интенсивность заболеваний в этих регионах будет расти, поэтому новые заболевания у детей до 14 лет регистрируются в 1,3–1,5 раза чаще, чему у взрослых и подростков.