New Geochemical Barrier to Detoxify of Soil from Arsenic and Mercury

Anar Kolushpayeva and Amankul Akbassova

Abstract—This article researches the problem of the violation of ecological balance in the ecosystem that is noticed in the last century and caused by the wastes of a huge amount of pollutants from anthropogenic sources. This problem causes much worries of the entire humankind. The given article reveals a problem of weeding soil from heavy metals, in particular from arsenic and mercury. The results of the researches to detect chemical surface of sorbents and their colloid-chemical and absorption-structural, ionic exchange and complex building properties serve to explain the migration of substances and also for rational selection of natural sorbents at the time of their using in different nature protecting technologies. Authors got a new geochemical barrier, consisting of a mixture of the utilized bird's dung, a marble crumb and a peroxide of calcium with the high absorbent activity. The research results allow to eliminate undesirable influence of heavy metals on plants and to get ecological clear products.

Index Terms—Geochemical barrier, peroxide of calcium, utilized bird's dung, detoxication.

I. INTRODUCTION

Soil system is a dimensionless stable system of living and nonliving components, in which external and internal cycles of matter and energy are continuously committed. It is a sphere of human habitation with all its social, spiritual and economic-economic activities.

This non-renewable, irreplaceable strategic natural resource is one of the main national wealth of any country. It is the basis of agricultural production, the main source of food. Apart from agricultural soil functions are performed by a number of environmental to ensure the stability of the biosphere and possible existence of life on the Earth. At the heart of the agricultural, environmental and other soil functions is its most important property - is fertility.

Under fertility of the soil to provide ability to understand plant energy and nutrients for the synthesis of organic matter, i.e., it is an integral indicator of the value of crop.

There distinguished a natural fertility, determinants of the genesis and artificial fertility, main factors which are nutrients (macro and micronutrients), energy (light, heat, etc.), pH, physical and chemical, biological and other processes, as well as their regimes, soil properties and states.

For macronutrients required for plant growth than carbon, oxygen and hydrogen are the following seven elements-nitrogen, phosphorus, potassium, calcium, magnesium, sulfur and iron. Plants require further apart macro-cells following microelements-manganese, boron, molybdenum, copper, zinc, cobalt, iodine, and others [1]-[5]. If the content of macro-elements in plants varies exceeding 10-6% [6]-[10].

Soil is a natural resource that is overexploited and polluted. In connection with this area of fertile land is dramatically reducing.

The negative impact of hazardous substances on objects of biogeocenososes appears in different ways, especially with respect to the soil, which is the main component and the foundation of operation of all terrestrial ecosystems.

Every year there is an increase of the intensity of soil environment pollution by heavy metals, so the search and development of effective environmental and economic methods of providing access to clean crop production is a challenge for the agricultural sector. Clarification of the laws governing the status and behavior of toxicants in the objects of the biosphere is one of the crucial and urgent scientific problems in the general problem of environmental protection. Migration of toxicants in the environment is defined by the set of processes among which adsorption plays a major role. Finding patterns of migration, accumulation, transformation and translocation of contaminants in the soil-plant is fundamental since the mechanism of the processes can be controlled by the behavior of toxic substances in specific environments which are established on their basis having created a safe and optimal conditions for the development of plants and plant communities that is an essential condition of life support of representatives of all the families of living organisms.

The certain scientific and practical interest about the solution to this issue is the creation of geochemical barriers in the soil system to inhibit the translocation of heavy metals in plants.

It is known that the toxic components are adsorbed by organic substances and many mineral components of soils, as a result there is a change in the level of their toxicity and bioavailability. Manifestation of the adverse effects of polluting substances in agroeco-system depends on the solubility of the pollutants, their mobility in soil and species characteristics of crops.
Analyzing data from the literature [11]-[14] and the results of our experiments [15]-[18] to study the sorption capacity of different materials for the management of migration, the translocation of As and Hg we have selected the geochemical barrier consisting of a mixture of recycled bird droppings, marble chips and calcium peroxide, which have high sorption.

II. METHOD

Calcium peroxide is a well-known commercial product which is manufactured on an industrial scale. It is widely used. The main decomposition products are hydrogen peroxide, oxygen, and thus it is used for bleaching, eliminating bad smells, as a local disinfectant. It is also known the use of calcium peroxide for agriculture to improve the growth of various crops at the expense of aeration as a result of the collapse of hydrogen peroxide to oxygen. When you add hydrogen peroxide it accelerates the process of decay. In addition the introduction of calcium peroxide into the soil makes it possible to adjust the pH value in the ecosystem due to the formation of Ca(OH)$_2$.

The use of calcium carbonate and hydrogen peroxide, bird droppings reduce significantly the flow of heavy metals into plants due to their adsorption properties.

Fig. 1 shows the experimentally obtained data describing sorption processes which take place with the participation of the components.

As it is seen from Fig. 1, a mixture of calcium carbonate and hydrogen peroxide in the ratio of 4:1, respectively has the best sorption capacity with respect to mercury. The same sorbent ratio was also the best during the sorption processes with arsenic. In this regard, further research is taken as a basis for our present composition of sorbents.

The sorption of arsenic decreases rapidly with decreasing acidity of the solution, which is associated with a form of existence of this element in the anionic form. Besides, the change in pH has an effect on the cation exchange capacity of the adsorption complexes, which occur when using a mixture of poultry manure, calcium carbonate and hydrogen peroxide (4:1:0.1) at different values of pH.

The pH value, s: 1 - 0 2-1.5-4.0; 3 - 6.8-8.0 4 - 8.0-10.0 5-10, 0-12,0 6- 13, 0

Fig. 2 presents data on the basis of these results, by which we can judge about the dependence of sorption processes on the pH of the environment from which the heavy metals are extracted. The data obtained are consistent and understandable in the light of the forms of arsenic and mercury in aquatic systems as a function of pH. Thus, with increasing of pH from 4 to 7 the intake of mercury in the plant is reduced by five times. The reason may lie in the formation of carbonate sediment, or the accumulation of hydroxo complexes HgOH$^+$ and Hg(OH)$_2$ in the solution, or in the decrease in the activity of free Hg$^{2+}$ ions due to their partial binding of ion pairs.

\[ K_{imm} = \frac{[C - Cc]}{C} \times 100\% \]

where $C$ is concentration of mobile forms of heavy metals in the soil prior to the introduction of sorbents;

$C_c$ is the concentration of mobile forms of heavy metals in the soil after application of sorbents.
As it can be seen from the data when introducing of calcium compounds together with bird droppings, which contain various organic compounds, immobilization ratio increases (Table II). In the presence of calcium carbonate and hydrogen peroxide, arsenic and mercury compounds are converted into particles of insoluble form and accumulated in the solid phase of soil system. Increase in the immobilization in the presence of bird droppings can be explained by the formation of complex compounds of humic acids, which they contain, with metals. Metals may be included both in anionic and cationic moiety in humic acid. Carboxyl and phenolic hydroxy groups are responsible for the formation of stable complexes with metal ions. Humic acid, having a high sorption capacity with respect to heavy metal ions behave as complexing sorbents. In addition, the heavy metals with a variable valence are able to interact with the N-and S-containing functional groups of organic compounds. This gives a basis to determine the role of poultry manure as a powerful geochemical barrier responsible for the concentration of metals in soils. Thus, the introduction of arsenic and mercury contaminated soil mixture of poultry manure, calcium carbonate and hydrogen peroxide can eliminate the undesirable effects of heavy metals on the plants and grow the environmentally friendly products.

### III. CONCLUSION

Thus, the introduction of arsenic and mercury contaminated soil mixture of poultry manure, calcium carbonate and hydrogen peroxide can eliminate the undesirable effects of heavy metals on the plants and grow the environmentally friendly products.

### REFERENCES

Anar Kolushpayeva was born on February 23, 1971. In 1993 she graduated from Kirov Kazakh State University, Department of Chemistry, Almaty, Kazakhstan. In 1996 she received the PhD degree in organic chemistry from Al-Farabi National University, Almaty, Kazakhstan. In 2006 she became a doctor of technical sciences from Tynyspayev Kazakh Academy of Transportation and Communication, Almaty, Kazakhstan. Additionally she has attended several seminars: 1. UNESCO Seminar on communication skills, climate changing held IN June 2006, Almaty; 2. Seminar on chemical science integration with industry by the help of innovations held In May 2011, Almaty; 3. International Teachers Summer Session held in May 2011, Almaty. She had a training in Malaysian Culture and Education Study Center, Taylor’s University, Malaysia University of California in 2011. Then in 2013 she had a long-term internship in Berkeley, Haas School of Business.

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