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# Opportunities of Getting Ecologically Safe Yield in the Technogenic Soils Contaminated with Heavy Metals under the Influence of the Complex Fertilizer Produced from Alumo-Silicates

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ABSTRACT

The article considers the study results on getting ecologically clean potato yield in the technogenic-contaminated soils through the application of the processed dacite tuff (PDT).

The experiments were carried out in the technogenic-contaminated soils at the Noyemberyan province, where the amounts of mobile heavy metals were considerably high.

The obtained results have disclosed that in case of using PDT (variants-$N_{120}P_{90}K_{90-150}$ (PDT)) in the fertilization system the content of heavy metals in the tubers was in the permissible limit. While in the control and $N_{120}P_{90}K_{90}$ (KCl) variants their amounts were much higher than the identified allowable threshold limits.

## Introduction

Food safety is an extremely important issue of strategic significance for each country and for its solution various innovative and advanced technologies are contributed to the agricultural production to increase the crops yield capacity; new land areas are used for cultivation through irrigation and reclamation activities and many other similar measures are taken (Galstyan, 2007, Avagyan, 1970, Mirzakhanyan, et. al, 2005, Mineev, et. al, 2006). When solving the mentioned problem it is of utmost importance that the resulted yield should be ecologically safe or have an ecologically permissible purity. Nevertheless, some intensively used agricultural land areas are located in the neighborhood of mining enterprises and have been contaminated with extremely harmful heavy metals and other harmful substances (Galstyan, 2007, Grigoryan, 1989) through irrigation water and dust. The consumption of yield resulted from such areas causes heavy and very often incurable diseases. Therefore, the development of the technologies for getting ecologically secure yield from the contaminated land areas is very actual and stems from the population's strategic requirements for the food safety assurance and improvement.

**Materials and methods**

The studies were carried out in conditions of Haghtanak community of Noyemberyan province at Tavush region in 2016-2018. The field experiments were implemented through the following scheme:

Without fertilization (control),

$N_{120}P_{90}$ (background),

Background +$K_{90}$ (KCl)

Background +$K_{90}$ (PDT)

Background +$K_{120}$ (PDT)

Background +$K_{150}$ (PDT)

The experiments were organized in three repetitions; the size of each experimental bed made 50 $m^2$. The plants necessary phenological observations, surveys and calculations were conducted during the vegetation. The yield was calculated through the method of real/actual harvest weighing, the data were subjected to the mathematical analyses with the identification of the trial error (Ex %) and the least significant difference ($LSD_{0.95}$ g) through the method of dispersion analysis (Khachatryan, 2002).

The evaluation of the tubers' quality was carried out through the accepted method (Yagodin, et. al, 1989). The content of heavy metals in the soil samples and tubers was determined through the atomic adsorption analyzer.

The content of soil humus, carbonates and mobile nutrients was also determined through the method common in our country (Yagodin, et. al, 1989).

The contamination rate of the experimental plots with heavy metals was identified according to the scale established by K.V. Grigoryan (Grigoryan, 1989).

**Results and discussions**

The mechanical composition of the soils for field experiments was light and clayey, the humus content in the genetic horizon "A" made 3.00 %, in "B" horizon – 0.82 %, carbonate content was 2.5 %-4.6 %, the environmental reaction (pH) was almost neutral -7.2-7.5. They were poorly provided with easily hydrolyzed nitrogen and phosphorus /4.5 mg-4.9 mg N and 2.2 mg-2.8 mg $P_2O_5$/, while the provision with the exchangeable potassium was average making 31.0 mg - 34.0 mg $K_2O$ in 100 g soil.

The experimental plots in Haghtanak and Derdzavan communities of Noyemberyan province are contaminated with heavy metals; particularly they are strongly contaminated with most dangerous pollutants Cu, Pb, Zn and Mn, while averagely contaminated with Mo (Table 1). Such situation is conditioned by the contamination with the heavy metals resulted from the nearby mining industries and river waters which are used for irrigation.

**Table 1.** Contamination rate of experimental plots with heavy metals (mg/kg in soil) according to the scale recommended by K.V. Grigoryan*

| Genetic horizons, cm | Cu | Pb | Zn | Mn | Mo |
|---|---|---|---|---|---|
| A O-25 | 221.6<br>39.7 | 50.3<br>5.9 | 71.3<br>21.7 | 832.0<br>249.0 | 13.8<br>2.13 |
| $B_1$ 25-46 | 113.6<br>24.7 | 84.1<br>10.0 | 65.6<br>16.1 | 1259.6<br>268.0 | 11.4<br>2.0 |

Note - The total quantity of an element is indicated in numerator, while the content of mobile forms is indicated in denominator.

** Composed by the authors*

Thus, the reclamation of so much contaminated soils in irrigation conditions is of utmost agro-technical and economic significance for the country with scarce land resources. The reclamation activities will enable to use the mentioned land areas for cultivation and to get ecologically clean yield. Our earlier studies have shown that it is possible to implement these activities upon the application of fertilizers which are endowed with high absorption capacity and are able to absorb the mobile forms of heavy metals from the environment. So, the quantity of heavy metals decrease in favor of plants, therefore ecologically permissible clean yield can be harvested from the mentioned land areas.

The processed dacite tuff (PDT) is considered to be such fertilizer, which is fabricated from the potassium-rich alumo-silicates through thermo-chemical method (Yeritsyan, et. al, 1993, Avagyan, 1970). This fertilizer contains potassium, calcium, magnesium, phosphorus and amorphous silicon dioxide and it is also endowed with such indirect positive features which are not characteristic to the mineral fertilizers. For instance its water absorption capacity makes about 500 %, absorption capacity- 45 mg/eq -50 mg/eq in 100 g soil. Moreover, it imbibes heavy metals in non-exchangeable way, while the light metals and $NH_4^+$ and $NO_3^-$ ions in an exchangeable way. The studies on the mentioned PDT properties have been conducted during the experiments of potato fertilization. The obtained data have shown that the application of the fertilizers has considerably influenced both the tuber's yield capacity (Table 2) and the tuber's qualitative indicators, as well as the content of its heavy metals (Table 3).

**Table 2.** The effect of the dosages of complex fertilizer (PDT) fabricated from alumo-silicates on the potato yield quantity and yield structure (average for 2016-2018)*

| N/N | Variants | Yield of potato tubers per years, c/ha | | | Average yield for three years, c/ha | Yield surplus | | Tubers' marketability, % | Average weight of the commercial tubers, g |
|---|---|---|---|---|---|---|---|---|---|
| | | 2016 | 2017 | 2018 | | c/ha | % | | |
| 1. | Control (without fertilization) | 152.0 | 164.0 | 159.0 | 158.3 | - | - | 66.8 | 69.8 |
| 2. | $N_{120}P_{90}$ -background | 275.0 | 262.0 | 270.0 | 269.0 | 110.7 | 69.9 | 81.2 | 87.2 |
| 3. | background + $K_{90}$ (KCl) | 294.0 | 286.0 | 293.0 | 291.0 | 132.7 | 83.8 | 82.4 | 89.0 |
| 4. | background + $K_{90}$ (PDT) | 300.0 | 308.0 | 310.0 | 306.0 | 147.7 | 93.3 | 89.2 | 93.0 |
| 5. | background + $K_{120}$ (PDT) | 329.0 | 323.0 | 339.0 | 330.0 | 172.0 | 108.7 | 93.6 | 95.6 |
| 6. | background + $K_{150}$ (PDT) | 332.0 | 336.0 | 341.0 | 336.3 | 178.0 | 112,4 | 93.8 | 96.0 |
| | Sx, % | 3.9 | 2.9 | 3.7 | | | | | |
| | LSD $_{0.95}$, g | 8.8 | 7.3 | 8.4 | | | | | |

**Table 3.** Effect of the application dosages of the complex fertilizer (PDT) fabricated from the alumo-silicates on the qualitative indices of the potato tubers and on the content of heavy metals*

| № | Variants | The average for the three years | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Dry substance, % | Starch, % | Vitamin C mg % | Nitrates, mg/kg | mg/kg in dry substance | | | | |
| | | | | | | Cu | Pb | Zn | Mn | Mo |
| 1 | Control (without fertilization) | 25.4 | 20.2 | 7.4 | 130.0 | 15.8 | 3.8 | 12.2 | 21.4 | 1.2 |
| 2 | $N_{120}P_{-90}$ - background | 26.6 | 24.4 | 8.0 | 165.0 | 13.9 | 3.2 | 12.3 | 20.9 | 1.3 |
| 3 | background +$K_{90}$ (KCL) | 27.2 | 24.6 | 8.2 | 170.0 | 14.0 | 3.2 | 12.0 | 21.5 | 1.2 |
| 4 | background +$K_{90}$ (PDT) | 27.6 | 25.0 | 8.2 | 170.0 | 10.0 | 2.2 | 8.9 | 6.4 | 0.7 |
| 5 | background +$K_{120}$ (PDT) | 28.9 | 25.6 | 8.3 | 175.0 | 8.5 | 1.7 | 6.0 | 5.2 | 0.5 |
| 6 | background +$K_{150}$ (PDT) | 29.0 | 25.6 | 8.2 | 175.0 | 8.0 | 1.5 | 6.1 | 4.9 | 0.4 |

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So, according to the 3-year average data the yield surplus in the fertilized variant has made 110.7 c/ha-178.0 c/ha against the control one. Besides, less surplus is observed in the background variant with the amount of 110.7 c/ha and then in the variant (132.7 c/ha) where potassium chloride together with the background (background + $K_{90}$KCl) has been used.

Meanwhile, when PDT was introduced together with the background, the tuber's yield surplus has made 147.7 c/ha-178.0 c/ha. Thus, when using PDT with same amount as the potassium the former has provided 15.0 c/ha (5.2 %) more yield as compared to that of the potassium chloride. In case of increasing the amount of PDT the yield capacity has increased even more amounting to 330.0 c/ha-336.3 c/ha, anyhow, the yield in the variant of background + K120 (PDT) is the most reliable. We believe that the high effect of PDT on the yield capacity is conditioned by the latter's positive side effects, i.e. it reclaims the soil properties and plants' nutrition (Yeritsyan, et. al, 1993, Yeritsyan &Farsiyan, 2016).

Application of PDT has also exerted a positive impact on the dry substance and starch content of the tuber's commercial yield (Table 3).

So, it is very important to harvest such yield from the soils contaminated with heavy metals in which the content of heavy metals is in the permissible threshold. In this regard some investigations have been carried out, which testify that the application of PDT on the background of nitrogenous and phosphoric fertilizers has significantly promoted the reduction of the content of heavy metals in the tubers. Besides, the reduction reached to the point, where the content of heavy metals is in the allowable threshold. It should be supplemented that this phenomenon is more obvious in the variants where PDT has been used with high dosages.

Thus, according to the average data for the three years, if in the variants of without fertilization, background, background + $K_{90}$(KCl) the content of heavy metals(Cu, Pb, Zn, Mn, Mo) exceeds the allowable threshold stated for those metals in 1.8-3.5 times (due to the Koltsov's scale, 1995, Agriecology, textbook-2000), then in case of applying PDT on the background of $N_{120}P_{90}$ with $K_{90,120}$ and $_{150}$ kg/ha dosages the content of heavy metals has decreased in 2.0 times for copper and zinc and for plumbum, molybdenum and manganese in 2.5, 4.3 and 3.0 times respectively. That is, in case of PDT application the content of the mentioned heavy metals in the yield is within the range of allowable threshold, therefore such yield is considered to be ecologically safe (Table 3).

**Conclusion**

Summing up the three-year results of the field and laboratory trials on potato we can draw the following conclusions:

1. The complex fertilizer PDT fabricated from the potassium-rich alumo-silicates is endowed with high absorption capacity; hence, it prevents the loss of nitrogen from the soil and imbibes the heavy metals, significantly decreasing their access into the yield fruits.

2. On the nitrogenous and phosphoric background the doses of K90 (PDT) and K150 (PDT) have provided a yield surplus with the amount of 15,0-45,3 c/ha as compared to that of recorded in KCl; at the same time a yield meeting the requirements of the eco-toxicological standards is produced.

3. It is recommended to use the processed dacite tuff for getting potato yield in compliance with the requirements of food safety standards in the strongly technogenically contaminated land areas.

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