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Cadmium Input to the Agricultural Soils with Phosphate Fertilizers in Turkey

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Inorganic fertilizers are commonly used in conventional agriculture in Turkey as well as around the world. Inorganic fertilizers such as phosphorus fertilizer may cause an inadvertent addition of heavy metals. This study was conducted to determine the soluble and total cadmium content of phosphorus fertilizer's type used agricultural lands of Turkey. For this prupose, soluble and total cadmium content of four different phosphate fertilizers, which are normal super phosphate (NSP), di ammonium phosphate (DAP), triple super phosphate (TSP) and mono ammonium phosphate (MAP) were determined with graphite oven attached atomic absorption spectrophotometer. The results showed that NSP (850 μ kg^{-1}) and DAP (2266 μ kg^{-1}) fertilizers have maximum water soluble and total cadmium content, respectively. In respect of maximum permissible cadmium content (1 mg kg^{-1}) of soils, it should be recognised that 2 mg kg^{-1} cadmium are supplemented to Turkish soils every year. With the estimation of 30.5 kg ha^{-1} phosphorus fertilizer use between 1972 and 2000 there for 2 g cadmium ha^{-1} was supplemented to Turkish soils within this period. Phosphorus fertilizers must be applied to the soil according to the crops' needs for phosphorus and available soil phosphorus status for sustainable agriculture. Future studies should be carried out to investigate cadmium and phosphorus downward movement and losses by leaching in soils.

Key Words: Cadmium, Phosphate fertilizer, Soil pollution.

INTRODUCTION

Sustainability of conventional agriculture is based upon a high input of agrochemicals, such as nitrate and phosphate fertilizers. Agricultural production is responsible for excess fertilizer application increases the nutrient load in waters. In Finland, phosphorus losses from agricultural soils by leaching and surface run-off account for 60 % of the anthropogenic load of phosphorus to surface waters, resulting in eutrophication[1].

There is another risk which concerns the inadvertent addition of impurities, such as heavy metals. The conventional inorganic phosphorus fertilizers

may cause an inadvertent addition of heavy metals to fertilizers, because commercial fertilizers and especially phosphate fertilizers are a potential source for global transport of metals. Phosphate fertilizers manufactured from rock phosphates and according to their origin, they may contain various trace and minor elements. These elements, when applied to soil, may persist due to their long life-time in soils and could be readily available for plants, especially in acid soils[2] with a potential risk of accumulation in soils and plants and transfer to human food chain[3].

Cadmium contents of agricultural lands sourced from parent material, atmosphere, fertilizer, agricultural chemicals, organic wastes and other inorganic pollutants and heavy metals. Cadmium in soils can only be removed with a small amount by phytoremediation, leaching and evaporation[4]. Sources of cadmium in soils consist of 55 % phosphorus fertilizer, 40 % atmosphere and 4 % sewage sludge. With the presence of heavy metals in atmosphere soils become to be polluted and this not only pollutes the soil but also pollutes the plants[5].

Phosphorus fertilizers applied for increasing yield may cause increasing cadmium levels on agricultural land. The rate of cadmium level depends on application rates of phosphorus fertilizers and soil characteristics[6,7]. As phosphorus fertilizers contain higher concentrations of cadmium than those present in the soil, their application, over time, increases soil cadmium concentrations[8,9]. Conversely, reported that long-term fertilizer phosphorus application did not elevate cadmium accumulation in soils. This might be the result of using phosphorus fertilizers containing lower rates of cadmium or plant uptake and removal of cadmium by leaching[10,11].

Cadmium can be bound in soil by simple electrostatic forces, or by association with metal oxides[12], carbonates and organic matter[13]. Cadmium solubility in soil depends on soil pH and other factors. Soil cadmium concentration decreases with increasing pH of soil[14]. The high pH and $CaCO_3$ contents in soils may elevate adsorption rates for phosphorus and cadmium by the formation of a surface complex of $CaCO_3$-P and cadmium[15,16].

Maximum permissible heavy metal content in soils should be cadmium 1 mg kg^{-1}, cobalt 10 mg kg^{-1}, copper 0.1 mg kg^{-1}, selenium 10 mg kg^{-1}, vanadium 0.5 mg kg^{-1} and nickel 100 mg kg^{-1}. Above this limit toxic effects can be seen on plants. Researchers also reported that cadmium not only forms toxicity and decrease in productivity but also it enters to the nutrient cycle[17-19].

Cadmium content of phosphate fertilizer depends on the origin of phosphate rock. The cadmium content of the phosphate rock were found high (< 500 mg kg^{-1}). In the USA, phosphate fertilizers are made of phosphorfluorite which consists of < 10 mg kg^{-1} cadmium. Researchers conducted this fertilizer showed that 0.3-1.2 g ha^{-1} cadmium is supplemented to soil

per year. 36 Year experiment conducted at the USA-California showed that fertilizers made by phosphate rock consist of 174 mg kg^{-1} cadmium and supplement 100 g ha^{-1} cadmium per year. Researches conducted in England presented that 3-4 mg kg^{-1} cadmium content of phosphorus fertilizer increase the cadmium content of soils 2 g ha^{-1} and 7.2 g ha^{-1} in cultivated and grasslands, respectively. Within the 10 years, 3.5 g ha^{-1} cadmium was added to soils in West Germany[20].

In Australia, cadmium is expected to decrease the plant nutrient quality. Maximum permissible content of cadmium in plants should be given as 0.1 ppm fresh $weight^{-1}$. There are a lots of researches conducted on soil and plant cadmium strategy[21-23].

The deterioration of cadmium to health is due to its take by vegetables and other agricultural crops. When consumed high levels of cadmium in plants accumulate in kidney and unbalance the phosphorus calcium content of body and cause skeleton problems in humans and animals[24]. In polluted lands cadmium content of the soils generally does not exceed 1 mg kg^{-1}. For phosphate fertilizer, phosphate cadmium content should not exceed 31-90 mg kg^{-1} and 38-48 mg kg^{-1}, respectively[25].

There are many reports are available in literature related to soil availability and total phosphorus contents in agricultural areas in Turkey. However, less research has been carried out in relation to cadmium content. The objective of this study was to evaluate concentration and variability of cadmium in solid phosphorus fertilizer materials of different origin.

EXPERIMENTAL

Fertilizer materials used in this study were consisted of three phosphatic fertilizer *viz.*, diammonium phosphate (DAP), triple superphosphate (TSP), normal superphosphate (NSP) and monoammonium phosphate (MAP). 50 Samples of each fertilizer were collected from all district of Turkey. All fertilizers were granulated. For determination of water soluble cadmium content, 1 g sample was placed in a 150 mL volumetric flask and shake for 0.5 h and then filtered through Whatman 42 filter paper. Soluble cadmium content in extraction was determined with graphite oven attached atomic adsorption spectrophotometer (AAS). Total cadmium content of fertilizers were determined as followed. 1 g sample was placed in a 150 mL flask and digestion was performed in a hotplate at 80 ºC with 25 mL of nitrich-perchloric acid during 45 min, than filtered through Whatmann 42 filter paper and extracted. Total cadmium content in extractions was determined with graphite surface attached AAS[26].

All results contained the mean values of duplicate analyses from 50 individual fertilizers. A descriptive analysis was performed using (SAS) statistical software programme[27].

RESULTS AND DISCUSSION

Soluble and total cadmium contents of phosphate fertilizers are given in Table-1. The NSP with 11 % use in Turkey manifested the highest soluble cadmium concentration among the fertilizers (850 ppb). The DAP with 67 % use showed the lowest soluble cadmium concentration among the fertilizers (252 ppb). Diammonium phosphate showed the highest total cadmium concentration with 2266 ppb (2.266 ppm) and TSP showed the lowest total cadmium concentration 1734 ppb among the fertilizers (Fig. 1).

TABLE-1
SOLUBLE AND TOTAL CADMIUM CONTENT OF PHOSPHATE FERTILIZERS USED IN TURKEY

Cadmium concentration means	NSP	DAP	TSP	MAP
Water soluble cadmium (μ kg^{-1})	850	252	323	362
Standard deviation (SD)	± 10	± 7	± 8	± 6
Coefficient of variation (CV)	22.1	15.1	9.6	21.5
Total cadmium (μ kg^{-1})	2161	2266	1734	2147
Standard deviation (SD)	± 24	± 11	± 9	± 10
Coefficient of variation (CV)	13.1	10.5	17.2	24.2

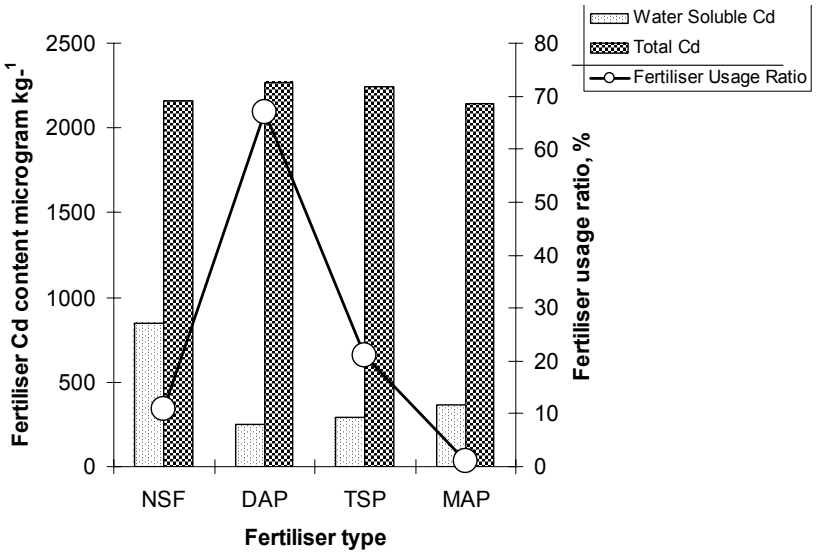

Fig. 1. Soluble and total cadmium content of phosphorus fertilizers used in Turkey

From the results, it was estimated that there was a cadmium entrance to the soil about 850-2266 ppb. As the cadmium limit taken for unpolluted soils (≤ 1 mg kg^{-1}), it is clearly seen from the results soils studies are under the great risk. With the estimation of 30.5 kg ha^{-1} $year^{-1}$ phosphate fertilizer use between 1972 and 2000[28], it is calculated that with the use of DAP (2266 ppm cadmium) every year 69.1 mg ha^{-1} cadmium was supplemented to Turkish soils.

Pollution of agricultural soils with fertilizers can be solved by limiting the total load of each heavy metal, especially cadmium. Taking into consideration pH, redox potential, organic matter and clay contents and other properties that reflect binding capacity of soil components, so that the soil could be maintained as a multi-functional system, without affecting biodiversity, another important quality that could be adversely affected by fertilizers[21].

Today there is an increasing concern about the entry of heavy metals, especially cadmium in to human food chain, hence continuous application could lead to accumulation and increase uptake by plants, especially of those exceeding natural abundance in soils. Knowledge of metal concentrations in fertilizer must be assessed in case of fertility trials or in continuous cropping systems where phosphate fertilizers are added to soils.

Conclusion

The result of this study indicate that with the estimation of 30.5 kg ha^{-1} phosphorus fertilizer use in Turkey between 1972 and 2000. This resulted 2 g cadmium ha^{-1} was supplemented to Turkish soils within this period. This result presents that cadmium pollution should be periodically observed in intensively fertilizer used in agricultural lands and should be catious about heavy metal development. Continuous fertilization of soils could increase the heavy metal contents exceeding natural abundance in soils and transfer these metals to the human food chain must not be overlook.

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