Egyptian Journal of Soil Science

http://ejss.journals.ekb.eg/

Effect of Different Phosphate Fertilizers on the Availability of some Heavy Metals in El-Gabal El Asfer Soil under Maize and Wheat Cropping System

Sara A. El-Shabasy, Abd Elmonem M. Hamissa, Nasser I. Talha and **Asmaa A. El-Basuny**
Soils, waters and Environment Research, Institute, Agriculture Research Centre, Giza, 12619, Egypt

THE AIM of this study was to investigate the influence of phosphorus fertilizers, on the availability of some heavy metals in soil El-Gable- El Asfer (irrigated with wastewater for 80 years). Two pots experiments were conducted under greenhouse conditions at Sakha Agriculture Research Station using maize *(Zea maize L.*) during growing summer season of 2020 and wheat (*Triticum aestivum L.*) during growing winter season 2020/21. Soil and plants samples were analyzed for their concentration of Zn, Ni and Cd. Furthermore, the immobilized metal percent, bioaccumulation factor (BAF) and translocation factors (TF) of the heavy metal were calculated. The treatments were, control, Super phosphate Sup_1 (71.4 kg P_2O_5 ha^{-1}), Sup_2 (142.8kg p_2O_5 ha^{-1}), diammonium phosphate DAP_1 (71.4 kg P_2O_5 ha^{-1}) and DAP_2 (142.8kg P_2O_5 ha^{-1}) for maize, and for wheat the treatments were, control, Sup_1 (36.89p_2O_5 ha^{-1}), Sup_2 (73.78 kg P_2O_5 ha^{-1}), DAP_1 (36.89 kg P_2O_5 ha^{-1} and DAP_2 (73.78 kg p_2O_5 ha^{-1}). The immobilized metal percent for the studied metals in the experiments soil can be arranged in the descending order Zn> Cd> Ni. The values of bioaccumulation factor (BAF) of Zn, Ni and Cd for maize roots and shoots can be arranged in the following order Cd > Ni > Zn. Data of translocation factor (TF) for the studied metal in maize and wheat, can be arranged in the following order Ni > Cd > Zn.

Keywords: El-Gabal- El Asfer, heavy metals, *Zea maize* L., *Triticum aestivm* L., immobilized metal%, Bioaccumulation factor, Translocation factor.

1. Introduction

In recent years, increasing attention has been paid to the issue of excessively high levels of heavy metals in agricultural products due to heavy metal pollution in the soil (**Wang et al. 2017).** These contaminants can't undergo degradation; therefore, possess serious potential risk for both human and animal (**Hashim et. al. 2017).** Using low quality water for irrigation is probably one of the main reasons for contaminating the arable lands with potentially toxic elements (**Farid et al. 2020). Nzihous and Sharrock (2010)**reported that soluble phosphate was widely investigated as a means of chemical treatment for the conversion of heavy metals into insoluble compounds. Phosphate compounds have been used to immobilize Pb, Cd and Zn metal by reducing their bioavailability. **Seshadri et al. (2017)** suggested that the super phosphate reactive (SPR) significantly reduced Pb, Cd and Zn leaching. While soluble diammonium phosphate (DAP) increased their leaching concentration, they also indicated that the differential effect of P- induced immobilization among P- compounds and metals is due to the variation in the solubility characteristics of P compounds and nature of metal phosphate compounds formed**. Chen et al. (2007)** reported that, hydroxyapatite (HA), phosphate rock (PR), triple super phosphate (TSP) and diammonium phosphate (DAP) were evaluated for their ability to reduce Cd, Pb and Zn bioavailability in an artificially metal-contaminated soil with three addition levels. The results showed that HA was superior to all other materials for reducing Pd, Zn and Cd uptake in shoot of plant (*Brassica Campestris* L.). **Yan et al. (2015)** studied the efficiency of four phosphate fertilizers, including Diammonium phosphate (DAP), Monobasic potassium phosphate (MPP), Calcium super phosphate (SSP) and Tribasic Calcium phosphate (TCP) in terms of the toxicity and bioavailability of Cd in contaminated soils. Results showed that the immobilization efficiency were in order MPP > DAP > SSP > TCP.

Mousavi et al. (2012) recorded that phosphorus is important element that interferes on Zn uptake, as Zinc uptake by plants reduces by increasing phosphorus in soil. In this respect, **Soltangheisi et al. (2013**) came to the conclusion that, Zn and P have antagonistic effect on the absorption and translocation of each other in plant. P- induced Zn

*Corresponding author e-mail: saraaelshabasy@gmail.com
Received: 28/02/2023; Accepted: 27/05/2023
DOI: 10.21608/EJSS.2023.196968.1574

deficiency is more common than Zn- induced P deficiency because growers commonly apply large amounts of P fertilizer as compared to Zn fertilizer. These results have to led the appearance of rosetting phenomenon. This phenomenon was evident in maize and did not appear in wheat, this could be explained by **Sirvastava (1996),** who reported that maize is sensitive to Zn deficiency while wheat is insensitive one.

Maize (*Zea mays L.*) and wheat (*Triticum aestivum L.)* were chosen for the green house pots experiments, whereas maize and wheat are the most important grain crops in north Africa. **Epule et al. (2022)** reported that maize is the main cereal crop in Africa accounted for over 60 percent of Africa wheat production. **Hang et al. (2018**) carried out a long-term field experiments with a wheat- maize rotation system to investigate the accumulation and bioavailability of heavy metals in calcareous soil at different rate of sewage sludge amendment. Bioconcentration factors (BCFS) can be used to indicate the transfer ability of heavy metal from soil to plant, they found that the (BCFS) of the heavy metal in wheat and maize grains were in order Zn > Cu > Cd > Hg > Ni > Cr > Pb > As.

This investigation amid to study the influence of phosphorus fertilizers levels and sources on bioaccumulation and translocation of Zn, Ni and Cd from contaminated soil to different parts of maize and wheat

Materials and Methods

1. Soil sampling

Soil samples were collected from 0-25 cm surface layer at the agricultural farm of El-Gabal El-Asfer located the North of Cairo, Al Qalyubia Governorate, Egypt, and continuously irrigated with sewage effluent for about 80 years. The sample was dried, ground sieved through 2 mm sieve. Some physical and chemical analysis was carried out according to the standard methods including Sparks et al. (2020) and Dane and Topp (2020). The soil was uniformly packed in plastic pots each of 23 cm height and 27 cm diameter at rate of 9 kg soil / pot.

2. Pot experiments

Two pot experiments were conducted under greenhouse conditions at Sakha Agriculture Research Station farm, Kafr El-Sheikh, Egypt during growing summer season of 2020 using (*Zea maize* L., cross 168 hybrid cultivar) and wheat (*Triticum aesttivum* L., Sakha 94 cultivar) during growing winter season of 2020/21. Each experiment was conducted in a completely randomized block design with four replicates. The treatments for maize were control (without phosphorus fertilizers), Sup_1 (71.4 kg P_2O_5 ha^{-1}, 2.12 g/pot), Sup_2 (142.8 kg P_2O_5 ha^{-1}, 4.24 g/pot), DAP_1 (71.4 kg P_2O_5 ha^{-1}, 0.62 g/pot) and DAP_2 (142.8 kg P_2O_5 ha^{-1}, 1.23 g/pot). The treatments for wheat were control, Sup_1 (36.89 kg P_2O_5 ha^{-1}, 1.06 g/pot), Sup_2 (73.78 kg P_2O_5 ha^{-1}, 2.12 g/pot), DAP_1 (36.89 kg P_2O_5 ha^{-1}, 0.31g/pot), DAP_2 (73.78 kg P_2O_5 ha^{-1}, 0.62 g/pot). Phosphorus fertilizers were incorporate into soil before sowing. All pots of maize and wheat were treated with the recommended doses of potassium fertilizer, in the form of potassium sulphate (48% K_2O) at rate of 119k ha^{-1} (0.55g/pot) before sowing.

Table 1. Some physical and chemical characteristics of the experimented soil.

Soil properties		value
Soil physical property		
Particle size distribution	Sand (%)	82.55 %
	Silt (%)	5.02 %
	Clay (%)	12.43 %
	Soil texture	Loamy sand
Soil chemical properties		
pH (1- 2.5 Soil water suspension)		6.88
EC, dS/m, soil paste extract		2.49
Organic matter , %		3.83
Total carbonate, %		3. 02
Soluble cations (cmolc kg^{-1} soil) Soil- past extract	Ca^{++}	11.316
	Mg^{++}	4.934
	Na^{+}	7.75
	K^{+}	0.80
Soluble anions (cmolc kg^{-1} soil). Soil- past extract	CO_3^{--}	-
	HCO_3^{-}	4.06
	Cl^{-}	8.64
	SO_4^{--}	12.1
DTPA- extractable metal (available) mg kg^{-1} soil	Cd	0.470
	Ni	3.73
	Zn	67.00
P available (mg/kg soil)	P	9.30

The recommended dose of nitrogen fertilizer for maize 285.6kg N ha^{-1} in form of urea (46% N) (2.84, 2.84, 2.7 and 2.57 g/pot,) for Sup_1, Sup_2, DAP_1 and DAP_2 treatments; respectively) splatted in three doses, the first dose after thinning, the second and third doses were applicated after three and four weeks from planting. The recommended dose of nitrogen fertilizer for wheat 166.66 kg N ha^{-1} in form of urea (46%N) (1.77, 1.77, 1.70 and 1.64 g/pot for Sup_1, Sup_2, DAP_1 and DAP_2 treatments respectively) was applied in three equal doses. The first dose after thinning, the second and third doses were applicated after 30 and 60 days from sowing. Six maize seeds and twelve wheat were planted in each pot at the 21^{th} of July 2020 and the 15^{th} of November 2020 / 21 respectively, pots were irrigated and just their moisture content at field capacity. After 15 days seeding were thinned to three and four Per pot of maize and wheat respectively, After 45 and 75 days from planting for maize and wheat respectively, plants height (cm) were measurement and then plant shoots and roots were harvested and washed by tab water followed by distilled water, oven dried at 70C for 48 hours. Dry matter was digested by using a mixture of sulphonic and perchloric acids**.** P, Zn, Ni and Cd were determined in digested plant material using atomic absorption spectrophotometer**.** Representative sample were collected from each pot after plant harvesting. The collected soil samples were air dried and prepared for chemical analysis according to the standard methods.

3. Calculation of immobilize metal, bioaccumulation and translocation factors

The effect of P fertilizer on bioavailability of Zn, Ni and Cd in the two experiments was evaluated by calculating of the immobilize metal% **(Seshari et al. 2017).** Bioaccumulation factor BAF (**Tesfaham et al. 2021**) and translocation factor TF **(Zheng et al. 2019).**

$$\text{Immobilized metal\%} = \frac{\text{DTPA extractable metal in control} - \text{DTPA extractable metal in sample}}{\text{DTPAextractable metal in control}} \times 100 \quad \textbf{Eq. (1)}$$

BAF = plant tissue metal concentration / soil metal concentration **Eq. (2)**

TF= shoot metals / Root metals **Eq. (3)**

Where, the soil and plant concentration are expressed in $mgkg^{-1}$ dry weight.

4**. Statistical analyses**

The experiments were conducted in a completely randomized block design (two phosphorus fertilizers, two levels from each one with four replications and control treatment). Data was statistically analysed according to **Gomez and Gomez (1984).** Treatment means were compared by using the least significant difference (LSD) at 0.05 level of probability, all statistical analysis using IRRITSTAT software.

Results and Discussion

1-Vegetative growth parameters:

Data of plant height, roots, shoots and biomass in maize and wheat plants significantly affected by phosphorus fertilizer treatments (Table 2).

Low values of EC and pH Table (1), this agrees with **Abbas and Bassouny (2018)** they explained that the values of EC and pH were 2 **dS/m** and 6.53 respectively on some sits in El- Gabal-El Asfar soil. Available p in the experimental soil is generally very high, this agrees with **Abuzaid (2018)** who explained that the wastewater irrigation improved fertility status, causing significant increases in total N and available P compared to the reference soil. Also, the high available P is due to the reductions occurred in soil pH owing to organic matter decomposition **(Abdelhafez et al. 2018).**

1-A- Maize

Plant height of maize as affected by P treatments can be arranged in the following descending order Sup_1 > Sup_2 > DAP_1 > DAP_2 = control. While the sequence of dry weight of root, shoot and biomass were in this order Sup_2 > Sup_1 > DAP_1 > DAP_2 = control, Sup_2 treatment was increased root, shoot and biomass by 24.98%, 32.59% and 31.13% respectively, as compared to control treatment. The positive effect of P-treatment on plant growth may be attributed to either the effect of P on decreasing metal toxicity, as estimated with tissue metal analyse, or improves P nutrition, or combination of both mechanisms. These results emphasized the effectiveness of Sup_2 treatment for increasing dry weight of maize plant. These results are similar to those of **Zein et al. (2009**) who reported that an increases in maize yield upon applying super phosphate at rate of 71.4 and 142.8 kg P_2O_5 ha^{-1}.

The lowest dry weight root, shoot and biomass were obtained by application of DAP_2 treatment. This may be attributed to the fact that high available P can cause P- induced Zn deficiency, a considerable increase occurred in the soil available phosphorus Table (3) upon applying DAP_2 at the same rate of Sup_2. This is probably due to its higher solubility. These results have led to the appearance of rosetting phenomenon. Many authors explained this phenomenon in Fig.1 like **Soltangheisi et al (2013),** who reported that zinc and phosphorus have antagonistic effect on the absorption and translocation of each other in plants. **Mian et al. (2021)** reported that, concentration of Zn in soil shows antagonistic effect with p and its concentration became linearly decreased with the increase in P rats. **Singh et al. (1988)** concluded that high P-concentration in root causes Zn to be tied up within the root cells. Zn becomes part of the fabric of the root and thus, becomes unavailable for transport to the leaves P may circumvent Zn in root by the formation of Zn- phytate. **Dwivedi et al. (1975),** in a pot experiment with maize suggested that at high P levels, Zn is immobilized not only with in the roots but also with in the nodes of stem. This is phenomenon was evident in maize and did not appear in wheat, This could be explained by **Srivastava (1996)** who reported that maize is sensitive to Zn deficiency while wheat is insensitive one.

Table 2. Yield and its components of maize (at the age of 45 days) and wheat (at the age of 75 days) as affected by levels and sources of phosphorus fertilizers.

Maize				
Treatment	**Plant height (cm)**	**Dry weight g /plant**		**Biomass g/ plant**
		Root	shoot	
Control	104.500 d	3.403 c	14.400 d	17.803 d
Sup_1	129.198 a	3.973 b	17.550 b	21.523b
Sup_2	127.180 b	4.253 a	19.093 a	23.346 a
DAP_1	116.405 c	3.421 c	16.660 c	20.081 c
DAP_2	106.415 d	3.326 c	14.003 d	17.329 d
Wheat				
Treatment	**Plant height (cm)**	**Dry weight g/plant**		**Biomass g/ plant**
		Root	shoot	
Control	72.000 c	0.690 d	4.580 e	5.270 d
Sup_1	78.500 b	0.790 c	6.410 d	7.210 c
Sup_2	80.500 b	1.450 a	7.380 a	8.830 a
DAP_1	85.250 a	1.290 b	6.880 b	8.170 b
DAP_2	78.250 b	1.280 b	6.720 c	8.000 b

Means followed by a common letter are not significantly different at level 5% according to DMRT. For Maize**:** Sup_1=71.4 kg P_2O_5 ha^{-1}, Sup_2= 142.8kg P_2O_5 ha^{-1} DAP_1=71.4kg P_2O_5 ha^{-1}, DAP_2= 142.8kg P_2O_5 ha^{-1}. For Wheat**:** Sup_1=36.89 kg P_2O_5 ha^{-1}, Sup_2= 73.78 kg P_2O_5 ha^{-1} DAP_1=36.89kg P_2O_5 ha^{-1}, DAP_2= 73.78 kg P_2O_5 ha^{-1}

Fig 1. Vegetative growth of maize plant at 45 days after sowing as affected by levels and sources of phosphorus fertilizers.

Table 3. Available phosphorus in soil as affected by levels and sources of phosphorus fertilizers.

Treatment	**After Maize**	**After Wheat**
	P mg Kg^{-1} soil	
Control	8.76 **d**	6.25 **e**
Sup_1	9.87 **b**	6.64 **d**
Sup_2	9.41 **c**	7.46 **c**
DAP_1	9.31 **e**	7.88 **b**
DAP_2	10.74 **a**	8.25 **a**

Means followed by a common letter are not significantly different at level 5% according to DMRT. For Maize**:** Sup_1=71.4 kg P_2O_5 ha^{-1}, Sup_2= 142.8kg P_2O_5 ha^{-1} DAP_1=71.4kg P_2O_5 ha^{-1}, DAP_2= 142.8kg P_2O_5 ha^{-1}. For Wheat**:** Sup_1=36.89 kg $P_2O_5ha^{-1}$ Sup_2= 73.78 kg P_2O_5 ha^{-1} DAP_1=36.89kg $P_2O_5ha^{-1}$, DAP_2= 73.78 kg P_2O_5 ha^{-1}

1-B- Wheat

The effectiveness of applied P- treatment on plant height of wheat can be in sequence of DAP_1> Sup_2 = Sup_1 = DAP_2 > control, While this arrangement of roots, shoots and biomass can be as follows Sup_2 > DAP_1> DAP_2> Sup_1> control. This result prove that Sup_2 treatment is superior to other on maize and wheat plants Sup_2 treatment increased roots, shoots, and biomass of wheat plant by 61.3%, 110.64% and 67.75% respectively, as compared with control treatment. This could be attributed to the functions of phosphorous in plants, a part of the protein molecule, necessary for transfer of energy during metabolic processes (ATP) and improving seedling vigor. These results reflect the beneficial influence of the P fertilizer in reducing the absorption of heavy metals, **Chen et al. (2007)** explain the effectiveness of different P sources in reducing the bioavailability of Pb, Zn and Cd in soils.

2- Effect of applied P- fertilizers on heavy metals immobilization in soil

Data in Table 4 show that available Zn, Ni, and Cd in the experimental soil significantly affected by Sup and DAP treatments, these materials have proven to be effective at reducing the solubility and bioavailability of heavy metal through the formation of metal-Phosphate minerals and /or Precipitates (**Chen, et al. 2007**).

2-A- Zn

Available Zn in soil after maize and wheat as affected by P-fertilization treatments can be arranged in this order control > DAP_1> DAP_2 and Sup_1 = Sup_2. The effectiveness of the P- treatments in decreasing metal availability can be assessed using immobilized metal % Table (5). Data of immobilized Zn % in soil sample maize Table (5) be can arranged in the following decreasing sequence Sup_1 > Sup_2> DAP_2> DAP_1 the corresponding values in soil samples wheat Sup_2> Sup_1> DAP_2> DAP_1.

Data in Table 4 indicated that Sup was more effective than DAP in reducing Zn bioavailability. This can probably by attributed to the application of DAP increasing metal availability due to its effect on decreasing soil PH. **Seshadri et al. (2017)** demonstrated that the differential effect of P induced Zn immobilization between P compounds and metal is due to the variation in the solubility characteristics of P-compounds and nature of metal phosphate compounds formed, the precipitation of $Zn_3(Po_3)_2$ has not been implicated with P-induced Zn deficiency because it has higher solubility than soil Zn **(Srivastava 1996).** Phosphorus fertilization increase specific sorption of Zn on crystalline Fe oxides **Xie and Mckenzie (1989).**

2-B- Nickel

Table (4) indicates that significant increases in the available Ni is affected by P- treatments in soil after maize harvested with an increasing percentage of 35.04%, 32.85%, 83.21% and 86.86% in Sup_1, Sup_2 DAP_1 and DAP_2 treatment, respectively compared with control treatment. While the data of available Ni concentration in soil after wheat was non significantly decreased by applying P- treatment. **Valipour et al. (2016)** reported that significant-decline in the availability of Pb and Cd after the application of triple super phosphate (TSP) but they found mobilization of Ni in soil, they explained that TSP treatment changed the Ni partition from most resistant fractions (Mn+Fe oxides, organic matter, and residual) to more mobile fraction (soluble + exchangeable and carbonate bound). The finding of **Majs (2011)** confirmed the redistribution of stable Ni to mobile fraction in the presence of P-treatments.

Table 4. DTPA extractable contents of Zn, Cd and Ni in soil as affected by levels and sources of phosphorus fertilizers.

Treatment	Maize			Wheat		
	mg kg^{-1}			mg kg^{-1}		
	Zn	Ni	Cd	Zn	Ni	Cd
Control	63.850 a	1.370 c	0.300 a	90.850 a	2.570 a	0.380 a
SuP_1	54.650 d	1.850 b	0.230 b	75.250c	2.430 a	0.350 b
Sup2	55.450 d	1.820 b	0.283 a	69.850 d	2.340 a	0.310 c
DAP_1	61.250 b	2.510 a	0.290 a	79.850 b	2.500 a	0.340 b
DAP_2	58.050 c	2.560 a	0.28. a	76.450 c	2.300 a	0.300 c
***Critical concentration in soil mg kg^{-1}**	**70 - 400**	**2 - 50**	**0.01- 0.70**	**70 - 400**	**2 - 50**	**0.01 - 0.70**

Means followed by a common letter are not significantly different at level 5% according to DMRT. For Maize: Sup_1=71.4 kg P_2O_5 ha^{-1}, Sup_2= 142.8kg P_2O_5 ha^{-1} DAP_1=71.4kg P_2O_5 ha^{-1}, DAP_2= 142.8kg P_2O_5 ha^{-1}. For Wheat: Sup_1=36.89 kg P_2O_5 ha^{-1}, Sup_2= 73.78 kg P_2O_5 ha^{-1} DAP_1=36.89kg P_2O_5 ha^{-1}, D AP_2= 73.78 kg P_2O_5 ha^{-1}

*According to **(Kapata- Pendias and Pendias 2001).**

Table 5. Effect of Phosphate fertilizers on mobility, bioaccumulation and translocation factors of Zn, Ni and Cd.

Heavy metal	P- treatment	Immobilized metal%		Bioaccumulation factor				Translocation factor	
		Maize	Wheat	Maize		Wheat		Maize	Wheat
				Root	shoot	Root	shoot		
Zn	**control**	NA	NA	1.72	0.50	0.46	0.29	0.29	0.64
	Sup1	14.41	17.17	1.29	0.27	0.48	0.28	0.21	0.61
	sup2	13.15	23.11	0.82	0.44	0.47	0.35	0.54	0.75
	DAP1	4.07	12.10	1.06	0.44	0.49	0.29	0.42	0.60
	DAP2	9.08	15.85	1.02	0.42	0.45	0.32	0.43	0.72
Mean		10.17	17.05	1.18	0.41	0.47	0.29	0.57	0.66
Ni	**control**	NA	NA	35.18	34.85	10.39	12.15	0.99	1.17
	Sup1	NA	5.45	18.51	22.98	14.40	14.71	1.24	1.02
	sup2	NA	8.95	20.47	24.03	17.73	16.80	1.17	0.94
	DAP1	NA	2.72	8.76	16.73	17.00	17.08	1.90	1.00
	DAP2	NA	10.50	10.74	17.57	14.49	12.06	1.63	1.13
Mean			6.90	18.73	23.24	14.80	14.56	1.38	1.05
Cd	**Control**	NA	NA	63.56	61.66	35.74	33.21	0.97	0.92
	Sup1	23.33	7.89	74.26	73.95	32.62	40.31	0.99	0.98
	sup2	6.67	18.42	65.75	62.22	49.74	53.74	0.95	1.08
	DAP1	3.33	10.52	42.00	56.37	49.47	43.05	1.35	0.87
	DAP2	6.67	21.05	51.64	62.67	48.03	30.06	1.21	1.32
Mean		10	14.47	59.44	63.36	43.12	40.07	1.09	1.03

Means followed by a common letter are not significantly different at level 5% according to DMRT. For Maize**:** Sup_1=71.4 kg P_2O_5 ha^{-1}, Sup_2= 142.8kg P_2O_5 ha^{-1} DAP_1=71.4kg P_2O_5 ha^{-1}, DAP_2= 142.8kg P_2O_5 ha^{-1}. For Wheat**:** Sup_1=36.89 kg P_2O_5 ha^{-1} Sup_2= 73.78 kg P_2O_5 ha^{-1} DAP_1=36.89kg P_2O_5 ha^{-1}, DAP_2= 73.78 kg P_2O_5 ha^{-1}.

2- C- Cadmium

Data in Table 4 showed that the P- treatments had non significantly effect on decreasing the available Cd in soil after maize, except for Sup_1 treatment, while applying P-treatments caused a significant decrease in available Cd in soil after wheat in all treatments, the concentration of available Cd in Sup_1, Sup_2, DAP_1 and DAP_2 treated soil after wheat decreased from 0.38 mg Cd\ kg soil (in control) to 0.35, 0.31 , 0.34 and 0.30 mg Cd kg soil $^{-1}$ respectively, with immobilization efficiency in order DAP_2 > Sup_2> DAP_1> Sup_1, Table (5).

These results revealed that, the addition of P treatment increased the soil available P, which mainly influences immobilization efficiency. This is agreement the finding of Yan et. al, (2015), who reported that DAP was highly effective in stabilizing Cd extracted from contaminated soil with a reduction of 44.05% and soil available Cd decreased by increasing addition DAP dose. On the other hand **Bogdanovie et al. (1999),** recorded that the application of increasing rates of P- fertilizer did not affect significantly the concentration of Cd in the soil.

Hong et al. (2010) showed that Cd solubility can be controlled using $Cd3(PO_4)_2$ in p- amended soils. The high solubility of Cd3(po4)2 decreasing the efficiency of P-fertilizers in Cd immobilization. Our results are in agreement with those obtained by **Andrunik et al. (2020)**. They conducted that phosphate amendments could effectively decrease Zn, pb, and Cd Leachability from soils. The concentration of these metals in contaminated soil was found to be in sequence of Zn >Ni > Cd.

3- Tissues concentration of Zn, Ni and Cd in roots and shoots of maize and wheat plants as affected by levels and sources of phosphorus fertilizers

Data in Table 6 showed that tissue Zn, Cd and Ni concentration of roots and shoots for maize and wheat was significantly affected with P- treatments.

3.1. Zn

Data in Table (6) revealed that P- treatments, Sup_1, $Sup_{2,}$ DAP_1 and DAP2 decreased Zn concentration in maize roots by 35.87%, 58.97%, 40.80% and 46.15% respectively compared to control treatment, for maize shoots by 53.6%, 22.5%, 14.3% and 21.16%. The corresponding values for wheat roots were, 14.76%, 21.59%, 6.19% and 18.81%, for shoots wheat were, 19.70 %, 8.38 %, 12.07 % and 8.086 %, the decreases in Zn concentration resulting from p addition could be attributed to increase biomass (dilution effect) and decreased bioavailability of Zn **(Seshari et. al, 2017).**

The efficiency of P- treatments to reduce Zn uptake by maize (roots and shoot) was more pronounced than by wheat, this is due to plant physiological factors **Mousavi et al. (2012)** and also to the crops differ in their susceptibility to Zn deficiency, corn is sensitive to Zn deficiency while wheat is insentive one **(Sirvastava, 1996)**. Data in Table (6) showed that Zn concentration in roots plants greater than in shoots. The values of BAF for Zn in roots were greater than for those shoots in maize and wheat Table (5). These results are in agreement with those of **Rezapour et al. (2019)** they concluded that the bioaccumulation and translocation factors of wheat showed heavy metals quantitatively accumulated in roots. This is mainly due to the slowly translocation of Zn from root to shoot which could be due to the formation of insoluble Zn-Phosphates **(Cao et al. (2009).** The results in Table (6) implicated that Sup_2 treatment could efficiently in decreasing Zn concentration in maize roots and shoot in the contaminated soils, Zn concentration in roots and shoots of maize plant decreased by increasing addition Sup and DAP dose. These results are similar to those of **Bogdanovie et al. (1999)** who reported that the uptake of Zn corn plants was significantly higher in the unfertilized check plot than plots fertilized with increasing P- rate.

3.2 Ni

Data in Table 6 indicate that P- treatments Sup_1, Sup_2, DAP_1 and DAP_2 decreased Ni concentration percentage significantly in maize roots by 28.93%, 22.7%, 54.35% and 42.93%, respectively compared to control treatment, The corresponding percentage of decrease in maize shoots were 10.95%, 8.37%, 12.04% and 5.67% respectively compared to control treatment., while P- treatments increased significantly Ni- concentration percentage in wheat roots and shoots. P- Treatment Sup_1, Sup_2, DAP_1 and DAP_2 increased the uptake of Ni in wheat roots by 31.08%, 55.43%, 59.18% and 24.83% respectively, compared to control treatment, the corresponding values by wheat shoots were 14.40%, 25.85%, 36.64% and 20.83%. These results could be explained that, maize plant is insensitive to Ni toxicity whereas wheat is firly resistant to Ni excess **(Luzzati and Siragusa 1986).** These results of Ni uptake in maize and wheat are in contrast with the results of available Ni in soil samples. **Sadiq, (1985)** reported that lead and Ni concentration in corn were not significantly correlated to their respective DTPA- extractable concentration in the experimental soils.

Table (6) reflects that the values of Ni in tissues plants ranging from 22.00 to 48.19 mg Ni kg^{-1} dry matter. However it did not appear toxicity symptoms on maize and wheat plants, these can be explained by **Jones and Hutchinson, (1988)** they observed that increasing phosphate in plants resulted in an increase in the tolerance of plants for Ni toxicity by formation of a potential binding site for detoxification of absorbed Ni.

3.3 Cd

The obtained results in Table 6 indicated that P- treatments Sup_1, Sup_2, DAP_1 and DAP_2 decreased Cd concentration in maize roots by 10.55%, 3.59%, 36.21% 24.27% respectively compared to control treatment. The corresponding values in maize shoots were 7.95%, 4.71%, 11.53% and 5.03%. This decrease in Cd concentration maize tissue could be attributed to increased biomass (dilution effect) in fertilized treatments and decreased bioavailability of metals **(Seshadri et al. 2017).** The concentrations of Cd in corn were significantly correlated to the DTPA– extractable concentration in the experimental soils **(Sadiq 1985).** While P- treatments Sup_1, Sup_2, DAP_1 and DAP_2 increased significantly Cd-uptake in wheat roots by 6.18%, 13.55%, 23.86% and 6.11% respectively, compared to control treatment, the corresponding values in wheat shoot were 11.81%, and 32.01%, 16.00% and 50.79%. Results of our finding are similar to those reported by **Cao et al. (2011**) they observed an immediate increase in Cd concentration when phosphate is applied and elevated Cd accumulation in wheat may be attributed to the competition between Zn and Cd for adsorption into plants **Grant et al. (2013**), revealed that Cd in phosphate fertilizer increase Cd availability for plant uptake and they reported that is discrepancy in the results related to Cd availability in long term P applied soil. **Grant e al. (2008)** reported that crop species and cultivars differ widely in their ability to take up and accumulation Cd, this is due to the genetic variation among cultivars

Table 6. Tissue concentration of Zn, Ni and Cd in roots and shoots of maize and wheat as affected by levels and sources of phosphorus fertilizers.

Treatment	Maize ($mg\ kg^{-1}$) Zn Root	Zn Shoot	Ni Root	Ni Shoot	Cd Root	Cd Shoot
Control	110.180 a	32.000 a	48.190 a	47.750 a	19.095 a	18.48 a
SuP1	70.730 b	14. 840 d	34.250 c	42.520 d	17.080 b	17.010 bc
Sup2	45.200 e	24.800 c	37.25 b	43.750 c	18.410 a	17.610 ab
DAP1	65.230 c	27.400 b	22.00 e	42.000 d	12.180 d	16.350 c
DAP2	59.330 d	25.230 c	27.500 d	45.000 b	14.460 c	17.550 ab
	Wheat ($mg\ kg^{-1}$)					
Treatment	**Zn root**	**Zn shoot**	**Ni root**	**Ni shoot**	**Cd root**	**Cd shoot**
Control	42.00 b	27.100 e	26.700 e	31.250 e	13.580 c	12.620 c
SuP1	35.800 c	21.000 c	35.000 c	35.750 d	14.420 d	14.110 b
Sup2	32.930 e	24.830 b	41.500 b	39.330 b	15.420 b	16.660 a
DAP1	39.400 a	23.830 d	42.500 a	42.700 a	16.820 a	14.640 b
DAP2	34.00 d	24.700 b	33.330 d	37.760 e	14.410 bc	9.020 d
***Critical concentration in plant ($mg\ kg^{-1}$)**	**100- 400**		**10- 100**		**5- 30**	

Means followed by a common letter are not significantly different at level 5% according to DMRT. For Maize**:** Sup_1=71.4 kg P_2O_5 ha^{-1}, Sup_2= 142.8kg P_2O_5 ha^{-1} DAP_1=71.4kg P_2O_5 ha^{-1}, DAP_2= 142.8kg P_2O_5 ha^{-1}. For Wheat**:** Sup_1=36.89 kg P_2O_5 ha^{-1}, Sup_2= 73.78 kg P_2O_5 ha^{-1} DAP_1=36.89kg P_2O_5 ha^{-1}, DAP_2= 73.78 kg P_2O_5 ha^{-1}

*According to **Kapata- Pendias and Pendias (2001).**

4-Bioaccumulation and Translocation factor

Bioaccumulation factor (BAF) can be used to indicate the transfer ability of heavy metals from soils to plants (**Tesfaham et al. 2021**). BAF = Cp / Cs where Cp (mg kg^{-1}) is the heavy metal content in maize or wheat roots or shoots, Cs is the content of the corresponding heavy metal in soil.

Plants are categorized as excluder if the, BAF values are <1.0, as influences if the BAF = 1 and as accumulator if their BAF values >1 **(Dessale welet et al. 2018).**

The BAF values of Zn in maize roots, BAF values of Ni and Cd in roots and shoots in maize and wheat Table (5) were >1 which indicates that the plants in all treatment accumulated the heavy metals, while the BAF values of Zn in maize shoots, wheat roots and shoots were <1.0 which indicate that the plants in all treatments absorbed but did not accumulated the heavy metals.

The values of BAF of heavy metals for maize roots and shoots in all treatments were greater than those of wheat Table (5) indicating that maize is more sensitive than wheat and could be used as an indicator plant, on the other hand **Hang et. al, (2018)** found that wheat is more sensitive than maize in calcareous.

The Translocation factor (TF) is one of the key parameters representing the migration capacity of heavy metal in plants **(Zheng et al. 2019).** Translocation factor (TF) was calculated as the ratio of transfer of heavy metal from root to shoot.

TF = Cs / Cr where Cs (mg kg^{-1}) is the heavy metal content in maize or wheat shoots, Cr (mg kg^{-1}) is the heavy metal content in maize or wheat roots.

TF values of Zn in maize Table (5) ranged between 0.54 and 0.21 with an average of 0.37, The corresponding TF values of Zn in wheat were ranged between 0.75 and 0.61. The high values of TF of Zn in maize and wheat were obtained by Sup_2 treatment, the values of Ni in maize in Table (5) were ranged between 1.90 and 0.99 with an average of 1.38 the corresponding TF values of Ni in wheat were ranged between 1.17 and 0.94 with an average of 1.05. The high values of TF of Ni in maize and wheat were obtained by DAP_1 and control treatments respectively. TF values of Cd in maize Table (5) were ranged between 1.35 and 0.95 with an average of 1.09, The corresponding TF Values of Ni in wheat were ranged between 1.32- 0.87 with an average of 1.03. The high values of TF for Ni in maize and wheat were obtained by DAP_1 and DAP_2 treatment respectively.

The average of TF values of Zn in wheat higher than in maize this indicated that the movement of Zn in wheat was higher, while the average of TF values of Ni and Cd in maize higher than values of wheat.

Data of translocation coefficient can be arranged according to mean values for maize and wheat in the following decreasing sequence Ni> Cd> Zn.

Conclusion

It can be concluded that under the condition of the applied research, the effect of phosphate fertilizers in the immobilization of heavy metal and its bioavailability on a contaminated soil with heavy metal (El- Gabal El- Asfer), may differ with type of phosphate fertilizers, plant and heavy metal element. The immobilized metal% for the studied metal in the experiments soil can be arranged in the descending order Zn > Cd > Ni. The values of bioaccumulation factor (BAF) of Zn, Ni and Cd for maize roots and shoots were greater than those of wheat, indicating that maize is more sensitive than wheat. Data of translocation factors (TF) for studied metal in maize and wheat according to mean values can be arranged in the following order Ni> Cd> Zn. High grade of field experiments are essential to determine whether phosphate fertilizers can be used to reduce the pollution of a contaminated soil with heavy metals.

References

Andrunik, M., M. Wolowiec., D. Wojnarskiec., S. Z. Pogudz and T. Bagda. (2020). Trans formation of Pb, Cd, and Zn minerals using phosphates. Minerals, 10 (4): P. 342.

Abbas, M. H. H and M.A. Bassouny. (2018). Implications of long-term irrigation with wastewater on the contents and retention kinetics of potentially toxic elements in typic torripsamment soils. Egypt. J. Soil Sci 58 (3): 337-357.

Abdelhafez , A. A., M.H.H., Abbas, T.M.S. Attia, W. El Bably and S.E. Mahrous, (2018). Mineralization of organic carbon and nitrogen in semi- arid soils under organic and inorganic fertilization, Environmental Technology& Innovation, 9: 243-253.

Abouzeid, A.S. (2018). Soil quality indicators in Al-Qalyubia governnorate as affected by long –term wastewater irrigation. Egypt. J. Soil Sci. 58 (1): 1-11.

Bogdanovie, D., U. Momcilo and M. Cuvardie, (1999). Effect of phosphorus fertilization on Zn and Cd contents in soil and corn plants. Nutrient Cycling in Agroecosystems 54: 49-56.

Cao. X., Flaten. D.N., Fenuta, M. Grimmett, M.G., Gawalko.E.J.,Grant, C.A., (2011). Soil soulation dynamics and plant uptake of cadmium and zinck by durum wheat following phosphate fertilization. Plant Soil. 338: 423- 434.

Cao, X., A. Wahbi., L. Ma, Y.B and Y, Li, Yang , (2009). Immobilization of Zn, Cu. and Pb in contaminated soils using phosphate rock and phosphoric acid. J. Hazard. Mater 164: 555- 564.

Chen, S., Xu. Minggang., Ma. Yibing and Y. Juncheng., (2007). Evaluation of different phosphate amendments on availability of metals in contaminated soil. Ecotoxicology and Environmental safety., 67:278-285.

Dane, J. H. and Topp, C. G. (2020). Methods of soil analysis”, Part 4: Physical methods (Vol. 20). John Wiley & Sons.

Dessalew, G., Beyene, A., Nebiyu, A., Astatkie, T., (2018). Effect of brewery spent diatomite sludge on trace metal availability in soil and uptake by wheat crop, and trace metal risk on human health through the consumption of wheat grain. Heliyon 4 (9), e 00783.

Dwivedi, R. S., N.S. Randhawa and R. L. Bansal, (1975). Phosphorus- Zinc Interaction Plant Soil, 43: 639-648.

Epule, T. E., C. Abdelghani and D. Dhiba. (2022). Recent patterns in maize yield and harvest area across Africa. IWRI. 12 (2), 374.

Farid, I.M., M.H.H. Abbas, M.A. Bassouny, A. Gameel, G. (2020). Indirect impacts of irrigation with low quality water on the environmental safety. Egypt. J. Soil. Sci. 60 (1): 1-15.

Grant. C., Flaten D., Tenuta M., Malhi S., Akinremi, W. (2013). The effect of rate and Cd concentration of repeated phosphate fertilizer applications on seed Cd concentration varies with crop type and environment. Plant Soil 372: 221-233.

Grant, C.A., J. M. Clarke, S. Duguid and R. L. Chaney. (2008). Selection and breeding of plant cultivars to minimize cadmium accumulation. Sci. Total Environ 390. 301- 310.

Gomez, K.A and Gomez, A.A. (1984). "Statistical Procedures for Agricultural Research" Joh Wiley and Sons, Inc., New York. pp: 680.

Hang., Y.H, Z. G. Yun, L.H. Lian, H.X., Mei, L. J., Mei and M.A., Bing. (2018). Accumulation and boavailability of heavy metals in a soil- w heat/ maize system with long- term sewage sludge amendments. J. Integrative agriculture 17 (8)1861:1870.

Hashsim, T. A., H. H., Abbas, I. M. Farid, O. H. M. El-Husseiny and M. H. H. Abbas. (2017). Accumulation of some heavy metals in plants and soils adjacent to Cairo- Alexandria Agricultural highway. Egypt. J. Soil Sci 57 (2): 215-232.

Hong, CO., D.Y., Chung and P.J., Kim. (2010). Comparison of phosphate materials for immobilizing cadmium in soil. Arch. Environ. Contam. Toxicol.58: 268-274.

Jones, M. D., and T. C. Hutchinson. (1988). Nickel toxicity in mycorrhizal birch seedlings infected with *Lactarius rufus* of *Scleroderma flavidum*.II. Uptake of nickel, calcium, magnanesium, phosphorus and iron. Newphytol. 108: 461-470.

Kabata- Pendias, A and H. Pendias (2001). Trace elements in soils and plants. 3rd CRC PRESS Inc. Boca Raton. Florida USA.

Luzzati. A., and N, Siragusa. (1986). The effect of increasing addition of nickel on plant growth and concentrations of nickel and nutrient elements in five plant species. Ann. Inst. Sper. Nutr. Piante (1985-86) 13, 28 pp.

Mian, A. M., Y. Anwar., S. Khan, M. W. Muhammad., M. Mussarat., M. Tariq, A. Usman., B. Khan., M. Adnan., K. Dawar., K. Ullah and J. Ali. (2021). Integrated influence of phosphorus and Zinc alogan with farmyard manure on the yield and nutrients uptake in spring maize. Egypt. J. soil. Sci. 61(2): 241- 258.

Macnicol, R.D., and P. H. T., Beckett. (1985). Critical tissue concentrations of potentially toxic elements. Plant Soil 85:107-129.

Majs, F. (2011). Potenntial adverse effects of applying phosphate amendments to immobilize soil contaminants, J. Environ. Qual. 1135-1142.

Mousavi, S. R., M. Galavi, and M. Rezaei. (2012). (The interaction of zinc with other elements in plants). IJACS Journal. 4 (24), 1881:1884.

Nzihous. A and P. Sharrock. (2010). Rol of phosphate in the Remediation and reuse of heavy metal polluted wastes and sites. Waste and biomass valorization. (1): 163- 174.

Rezapour, S., B. Atashpaz, S. S. Moghaddam and C. A. Damalas. (2019). Heavy metal bioavailability and accumulation in winter wheat (*Triticum aestivum* L.) irrigated with treated wastewater in calcareous soils. 656: 261-269.

Seshadri, B., N. S. Bolan., G. Choppala., A. Kunhikrishnan., P. Sanderson., H. Wang., L. D. Tsang., Y.S. OK and K. Kim. (2017). Potential Value of phosphate compounds in enhancing immobilization and reducing bioavailability of mixed heavy metal contaminants in shooting range soil.J. 184:197-206.

Soltangheisi A., F. C. Ishak., M. H. Musa., H. Zakikhani and A. Z. Rahman. (2013). Phosphorus and Zink Uptake and Their Interaction Effect on Dry matter and Chlorophal Content of sweet Corn (*Zea Mays* var. Sacchrata). J. Heliyon. 7. 1e05989.

Srivastava, P. C. (1996). Trace Elements in Crop Production. Science Puplishers, Inc.

Singh, J. P., R. E. Karamanos and J. W. B. Stewaart, (1988). The mchanism of phosphorus-induced Zinc deficiency in bean (*Phaseoius vulgaris* L.). Can. J. Soil Sci. 68:345-358.

Sadiq., M, (1985). Uptake of Cadmium lead and Nickel by Corn Grown in contaminated soils. J. water, Air and soil pollution, 26:185- 1950.

Sparks, D. L., Page, A. L., Helmke, P. A and Loeppert, R. H. (2020). Methods of soil analysis, part 3: Chemical methods (Vol. 14). John Wiley & Sons.

Tesfahun, W., A. Zerfu, M. Shumuye, G. Abera , A. Kidane and T. Astatkie, (2021). Effects of brewery sludge on soil chemical properties, trace metal availability and uptake by wheat crop, and bioaccumulation factor. Heliyon. (7): e05989.

Valipour, M., K., Shahbazi and A., Khanmirzaei. (2016). Chemical immobilization of lead cadmium, copper, and nickel in contarminated soils by phosphates amendments. CLEAN-Soil, Air; Water 44: 572- 578.

Wang, S., W. u, W., L, Fei. L.Rrnkuan, H. Yaqi. (2017). Accumulation of heavy metals in soil-crop systems a review for wheat and corn. Environ Sci Pollut 24: 15209-1525.

Williams, D. E., (1949). A rapid manometric method for determination of Carbonates in soil. Soil.Soc. Amer. Proc. Vol. BPP, 127- 129.

Xie, R. J. and A. F. Mackenzie, (1989). Effects of sorbed orthophate on Zinc status in three soils of eastern Canada. J. Soil Sci. (U. K) 40: 49- 58.

Yan, Y., Y. Q. Zhou and C.H. Liang., (2015). Evaluation of Phosphate Fertilizers for the Immobilization of Cd in Contaminated Soils. J. PLOS 10:137.

Zein, F. I; Asmaa A. El-Bassuony and H. S. Hamoud., (2009). Maize response to zinc application under different phosphorus fertilization levels, its nutrients uptake, and availability in allouvial soils. J. Agric. Sci. Mansoura. Univ., 34 (5): 5683- 5704.

Zheng, L., B. Ying and Y. Tongming, (2019). Effect of Cd on the uptake and translocation of Pd, Cu, Zn and Ni in potato and wheat grown in sierozem. J. Soil and sediment contamination, 28 (7).