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The Impact of Phosphorus Fertilizers on Heavy Metals Content of Soils and Vegetables Grown on Selected Farms in Jordan

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OUTLINE

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INTRODUCTION

- **Phosphorous** (**P**) is considered an essential nutrient element for plant growth and development.
- **P** deficiency constitutes a major limiting factor in the crop production of the world (George and Richardson, 2008).

INTRODUCTION

- **Heavy metals** like cadmium (**Cd**), lead (**Pb**) and arsenic (**As**) metalloid have been found in **P fertilizers** and are considered the most important of health concern (Minnesota Department of Health, 1999).
- These elements are regarded **toxic** and classified as **carcinogenic** (Mensah, et al., 2009; Oymen et al., 2015).

INTRODUCTION

- **Cadmium** is a highly **mobile** metal and found to accumulate in plants in large amounts without showing **phytotoxic** symptoms.
- Therefore, it is considered as one of the most serious heavy metals to human health (Moustakas et al., 2001; Kirkham, 2006; Al-Faiyz, et al., 2007).

INTRODUCTION

- Moreover, **Cd** tends to accumulate in vegetables more than other heavy metals;
- For this reason **Cd** can enter the **food chain** by ingestion of vegetables (Podar and Ramsey, 2005).

INTRODUCTION

- Recent studies, also, have demonstrated that **As** and other toxic heavy metals like **Cd** and **Pb** were responsible for causing a chronic **kidney** disease, known as toxic **nephropathy**, in contaminated areas in **Siri Lanka** (Jayasumara et al., 2015).

INTRODUCTION

- Also, **poisoning** by **Pb** in **Nigeria** killed more than **500** children, and left thousands in severe health conditions in 2010 (Galadima and Garba, 2012; Agwaramgbo et al., 2014).

Children poisoned by lead (Pb) from Gummi, Zamfara state, Nigeria (Galadima and Garba, 2012).

INTRODUCTION

- On the other hand, local research works have indicated that heavy metals like **Cd** and **Pb** are found in **phosphate rock** of **Jordan** which is used primarily in the production of **P fertilizers** (Javied, et al., 2009; Alkhader and Abu Rayyan, 2014).

Objective

- The objective of this study is to investigate the possible **contamination** of **soils, plants, P fertilizers and irrigation water** in selected intensively cultivated areas in Jordan, with heavy metals (**Cd** and **Pb**) and **As** metalloid.

Objective

- **Lettuce** (*Lactuca sativa* L.) showed a high capability to absorb **Cd** from the soil and considered an **accumulator** for **heavy metals** in its leave tissues (Smical, et al., 2008; Yargholi et al., 2008).

Objective

- Therefore, **lettuce** (*Lactuca sativa* L.)was used as an **indicator** plant for potential heavy metals **contamination** of vegetables.

MATERIALS AND METHODS

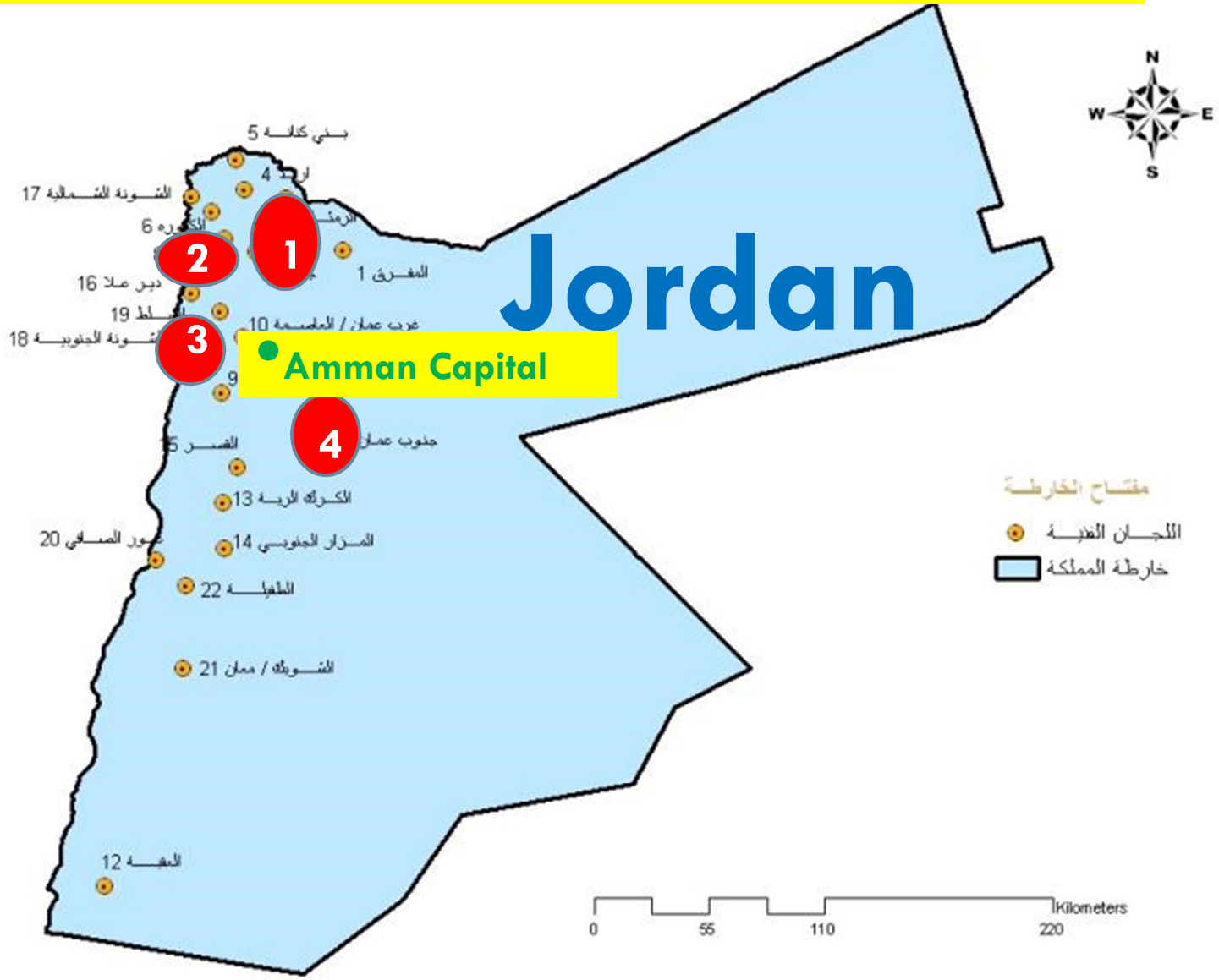
1. Farms Selection

- **Thirteen** (**13**)farms from **three** (**3**)locations characterized by intensive agricultural activities in Jordan (**Jordan Valley, Alyadoda, and Jarash**) were selected for sampling :

1. **soil,**
2. **plant,**
3. **fertilizers**
4. **and irrigation water**

- During the spring/summer period of the 2010 year.

The agricultural sites of heavy metals investigation in the conducted survey in Jordan



MATERIALS AND METHODS

2. Soil

- **Three** (3) **composite** soil samples (0-20 cm depth) were collected from each selected farm for some **chemical** and **physical** analysis.
- Soil 0.005 M DTPA-extractable **Cd** and **Pb**, and 0.5 M $NaHCO_3$-extractable **As** were determined (**bioavailable** to plant).
- **Atomic absorption spectrophotometer** (AAS) (Model Varian, Spectr. AA-200, Australia) was used in these determinations.

MATERIALS AND METHODS

3. Fertilizer

- Levels of heavy metals (**Cd** and **Pb**) and metalloid (**As**) were determined in ten (**10**) **P fertilizers** which are widely used in the investigated farms.

MATERIALS AND METHODS

4. Irrigation Water

- Chemical analysis was done for the irrigation water samples collected from the investigated farms to determine pH, EC, major cations and anions (**routine analysis**)
- **Cadmium**, **Pb** and **As** concentrations were, also, measured.

MATERIALS AND METHODS

5. Plant

- **Lettuce** plant (**iceberg** type) samples were collected from **three** (**3**) farms which were cultivated with this crop.
- **Three** (**3**) plants from each farm were used to make representative samples.
- The plant contents of **Cadmium**, **Pb** and **As** concentrations were measured using AAS.
- Measurements were taken in triplicate and averaged.

RESULTS AND DISCUSSION

1. Chemical and physical analysis for the soils

Table 1: Average values for some chemical and physical properties of the soils (0-20 cm depth) from the selected farms in the conducted survey in the year 2010.

Farm no.	Location	pH	Salinity	Total N	Available		Extractable			Texture
					P	K	Cd	Pb	As	
			dS/m	%	ppm					
1	Middle Jordan Valley	8.1	2.76	0.08	23.1	572.9	0.028	0.62	9.04	Clay
2		8.0	1.26	0.22	130.4	730.9	0.066	0.78	7.45	
3		8.2	24.2	0.12	63.7	461.3	0.158	0.84	16.41	
4		8.1	3.47	0.14	98.4	535.7	0.058	0.92	0.69	
5		8.2	2.05	0.07	87	284.7	0.024	0.56	12.56	Clay loam
6		8.3	1.96	0.12	97.6	479.9	0.044	0.74	4.99	
7		8.2	2.28	0.08	70.6	294	0.014	0.46	2.69	Sandy clay loam
8		8.1	5.72	0.06	42.9	396.2	0.136	0.72	7.92	Clay loam
9		8.2	1.52	0.08	68.4	275.4	0.022	1.9	17.77	Sandy clay loam
10	Southern Jordan Valley/cultivated	8.7	27.3	0.1	84.9	684.4	0.028	0.4	16.24	Sandy clay loam
	Southern Jordan Valley/uncultivated	8.5	32.8	0.02	4.9	331.1	0.01	0.64	0.85	Sandy loam
11	Al-Yadoda	7.9	1.13	0.14	81.4	572.9	0.216	0.84	2.46	Clay
12		8.3	0.65	0.09	33.1	377.6	0.11	0.9	1.08	
13	Jarash	8.0	1.95	0.08	17.9	563.6	0.024	0.52	0.75	Clay

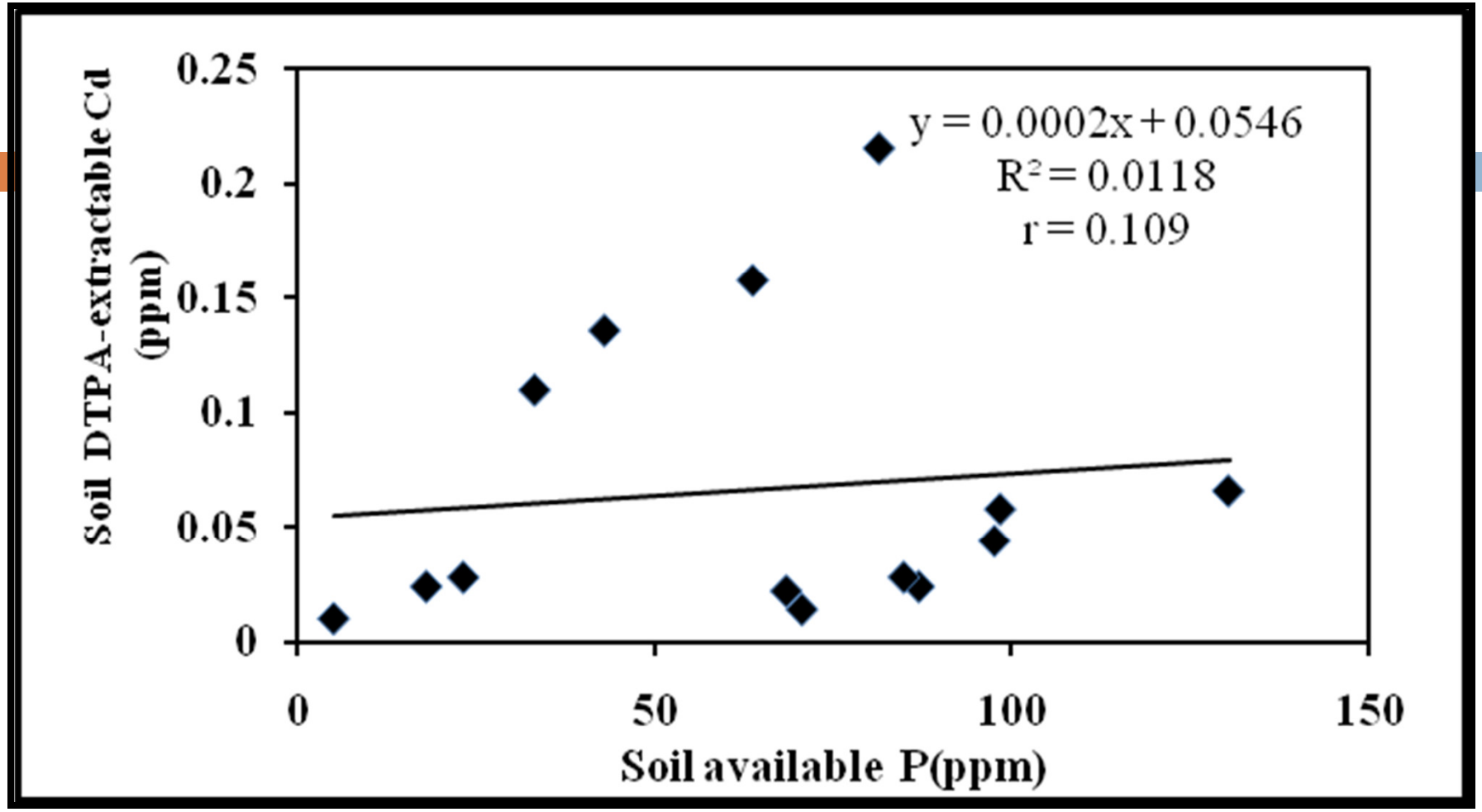


Figure 1a: The correlation between soil available P and soil DTPA- extractable Cd in the selected farms.

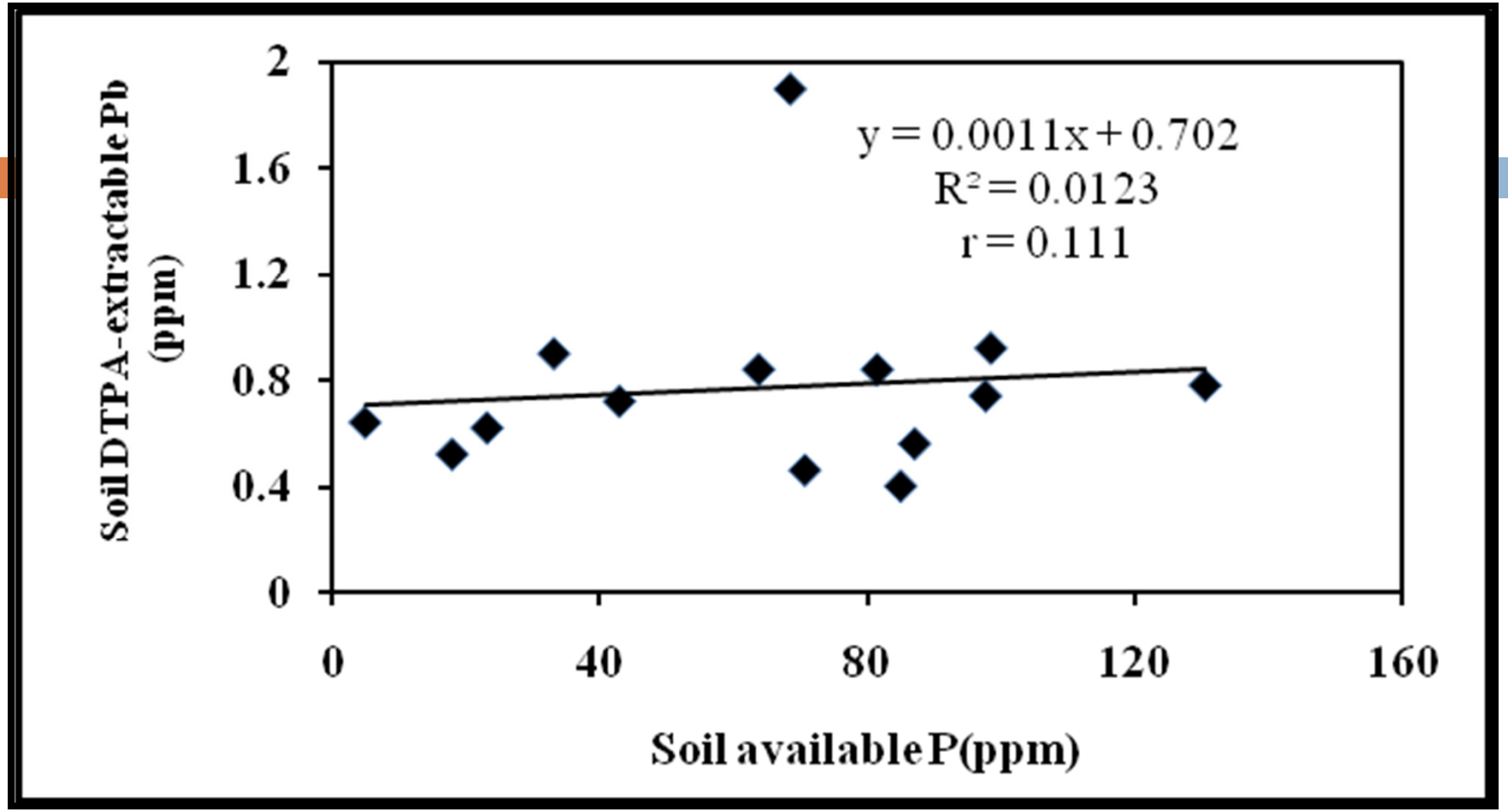


Figure 1b: The correlation between soil available P and soil DTPA- extractable Pb in the selected farms.

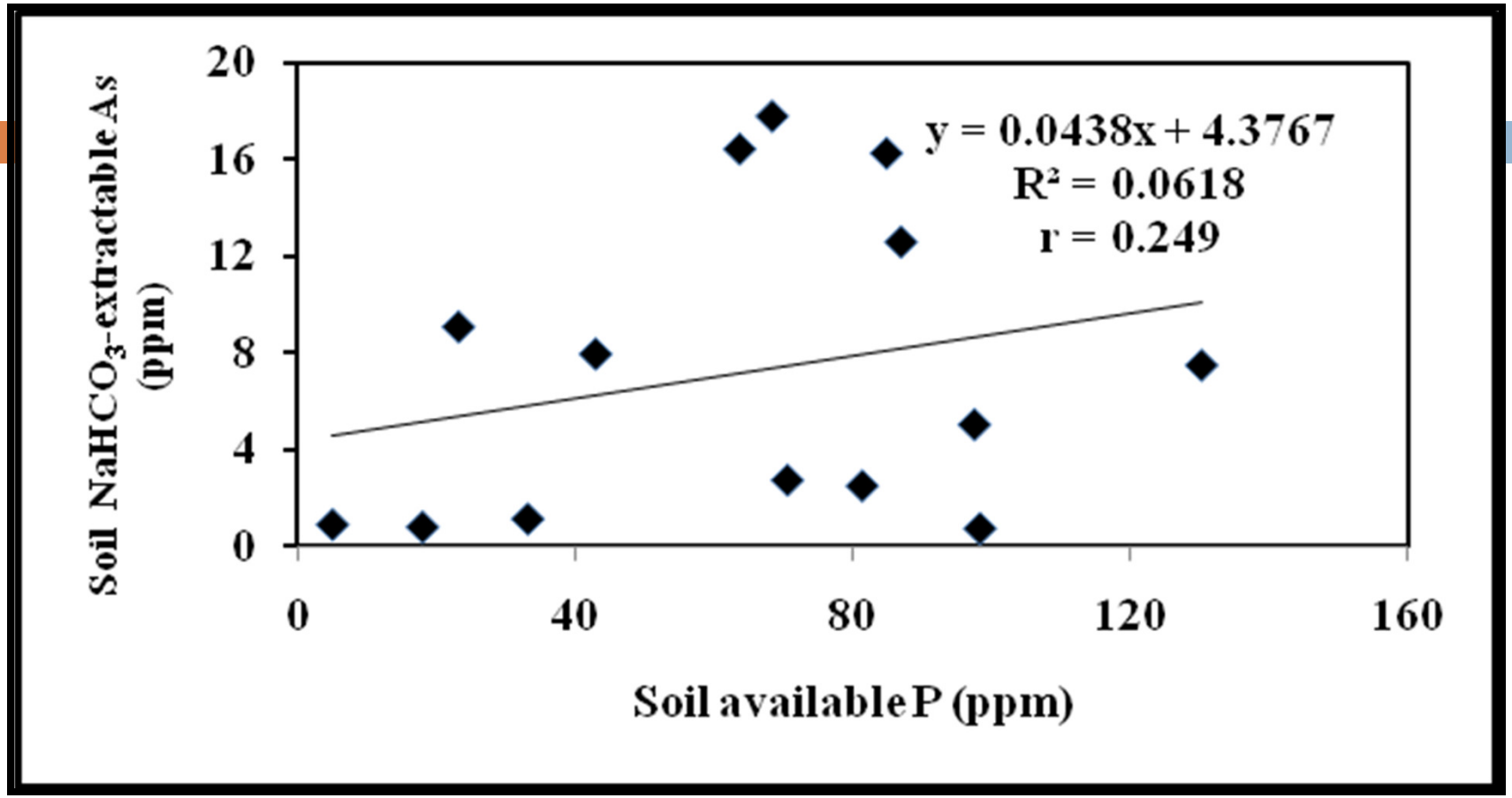


Figure 1c: The correlation between soil available P and soil $NaHCO_3$-extractable As in the selected farms.

2. Chemical analysis for fertilizers

Table 2: Average values of some nutrients and heavy metals contents for some selected chemical fertilizers usually used by farmers in Jordan.

Fertilizer	Nutrients			Heavy metals*		
	N	P_2O_5	K_2O	Cd	Pb	As
	%			ppm		
1. Urea Phosphate	17.4	46.7	0	2.76	0.4	13.74
2. DAP	18.2	44.0	0	7.9	2.1	2.8
3. MAP	12.3	61.1	0	0.5	1.8	43.0
4. SSP	0	17.4	0	6.1	2.2	5.5
5. NPK	13	40	13	1.02	5.8	0.26
6. NPK	15	15	30	0.7	6	3.77
7. NPK	30	10	10	0.42	3.4	7.85
8. NPK	20	5	10	0.6	5	1.85
9. NPK	19	19	19	0.86	5.6	16.36
10. NPK	16	8	24	0.8	8.2	0.70

*** The critical limits of Cd, Pb and As in chemical fertilizers are 20, 500, and 75 ppm, respectively, according to the Canadian Standards (Heckman, 2006).**

3. Chemical analysis for the irrigation water

Table 3: Results of chemical analysis for the irrigation water samples from the selected farms.

Farm no.	Location	pH	EC	*Cd	*Pb	*As
			dS/m	(ppm)		(ppb)
1	Middle Jordan Valley	7.1	2.2	<0.002	<0.01	< 0.2
2		7.3	1.4	<0.002	<0.01	< 0.2
3		7.2	3.4	<0.002	<0.01	< 0.2
4		8.3	2.3	<0.002	<0.01	< 0.2
5		8.4	1.7	<0.002	<0.01	< 0.2
6		8.4	1.7	<0.002	<0.01	< 0.2
7		8.3	1.7	<0.002	<0.01	< 0.2
8		8.4	1.7	<0.002	<0.01	< 0.2
9		8.3	1.8	<0.002	<0.01	< 0.2
10	Southern Jordan Valley	8.4	1.8	<0.002	<0.01	< 0.2
11	Al-Yadoda	7.6	0.9	<0.002	<0.01	< 0.2
12		7.7	0.7	<0.002	<0.01	< 0.2
13	Jarash	7.7	0.8	<0.002	<0.01	< 0.2

* The levels are below instrument detection limit.

4. Chemical analysis for lettuce plant

Table 4: Average values of the heavy metals (Cd, Pb), metalloid (As) and nutrients (N, P and K) content of lettuce plant (iceberg type) from three investigated farms.

Farm no.	*Cd	*Pb	*As	N	P	K
	(ppm)		(ppb)	%		
	Fresh weight basis			Dry weight basis		
11	0.05	0.20	10.76	3.50	0.65	12.09
12	0.04	0.25	12.76	3.31	0.62	11.50
13	0.03	0.12	12.78	2.56	0.61	7.59

***The tolerable limits of Cd , Pb and As are 0.2, 0.3 and 1 mg kg^{-1} of fresh mass, respectively (EC, 2006).**

CONCLUSIONS

- **Lettuce** which was considered as an **indicator** plant for potential heavy metals **contamination** of vegetables was within the allowable levels of **Cd** and **Pb** (**0.2** and **0.3** mg kg^{-1} of fresh weight for leafy vegetables, respectively).

CONCLUSIONS

- The plant was, also, safe with respect to **As** as the level of this metalloid was much less than the established acceptable concentration of **1** mg kg^{-1} fresh mass.

CONCLUSIONS

- However, long term applications of **P fertilizers** (and pesticides) are likely sources of heavy metals in agricultural soils and crops in Jordan.

- This, essentially, may constitute a threat to the human health and surrounding environment.

RECOMMENDATIONS

- A national strategy should be developed and adopted in Jordan to monitor and minimize the concentration of the heavy metals and inputs into agricultural soils and their transfer to the plant crops.

RECOMMENDATIONS

- This could help protect the environment from pollution and, thus, jeopardy to the human health could be reduced.

Thanks for your attention