



Fayoum University
Faculty of Science
Botany Department

**Study on some heavy metals as pollution indicators of
soil, plants and water at east of Fayoum province,
Egypt**

By

Nourhan Reda Mohamed Abdel Samie

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B.Sc. in Botany and Chemistry 2020
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Supervision Committee:

1. Prof. Dr. Tharwat El-Sayed El-Desouky Radwan

Professor of microbiology, Botany Department, Faculty of Science, Fayoum University.

Signature:

.....

2. Dr. Sameh Ali Amin Ismail

Lecturer of Plant Ecology, Botany Department, Faculty of Science, Fayoum University.

Signature:

.....

Approval Sheet

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This Thesis for M.Sc. degree has been discussed and approved by:

The Discussion committee:

1. Prof. Dr. Yasser Hassan Ibrahim

Professor of plant ecology, Air pollution Department, National Research Center

Signature:

2. Prof. Dr. Mohamed Ahmed Moustafa Shahba

Professor of plant ecology, Department of Natural Resources, Faculty of African Postgraduate Studies, Cairo University

Signature:

3. Prof. Dr. Tharwat El-Sayed El-Desouky Radwan

Professor of microbiology, Botany Department, Faculty of Science, Fayoum University.

Signature:

.....

5. Summary and Conclusion

Heavy metal contamination has recently been an emerging ecological disaster due to its persistence, non-biodegradability, and potential influence on the environment and human health.

The main objective was to study the concentration and distribution of some HMs (Cd, Ni, Pb, and Mn) in the soil, water, and some plants along the Eastern region of Fayoum Governorate. Moreover, we evaluated the degree of contamination, the level of ecological risk, and the degree of anthropogenic enrichment for the selected metals in soil and water samples using single and integrated indices. Additionally, non-carcinogenic and carcinogenic health risks were evaluated for adults and children.

Results obtained could be summarized in the following:

I- Soil samples

- Soil pH ranged between 6.90 and 8.12. Soil organic matter content ranged between 0.52% and 2.40%. The values of CaCO_3 ranged between 8.03 and 32.90%. EC_e ranged between 2.01 and 14.25 ds/m. The mean concentration of major cations (mmol/L) showed the following sequence: Na^+ (27.49) > Mg^{2+} (15.51) > Ca^{2+} (9.03) > K^+ (3.78). The mean concentration of major anions (mmol/L) showed the following sequence: Cl^- (24.75) > SO_4^{2-} (22.87) > HCO_3^- (8.16) > CO_3^{2-} (0.00). The SAR ranged between 3.15 and 42.77.
- The results show that the mean concentrations of the examined HMs (mg kg^{-1}) followed the order: Mn (350.35) > Pb (205.83) > Ni (78.48) > Cd (13.57).
- The heavy metals' CF_s values arranged in the following order: Cd > Pb > Ni > Mn. C_{ds} referred to a high degree of contamination according

to UCC, AWS, and UCES reference values, while they showed a moderate degree of contamination according to FAO reference values.

- The mean Er_i followed the trend as $Cd > Pb > Ni > Mn$. The UCC and UCES reference values indicated high ecological risk. Nevertheless, FAO and AWS reference values suggested moderate and considerable ecological risk, respectively.

- The mean EF_s values of HMs decreased in the following order: $Cd > Pb > Ni$. Generally, the mean EF_s values demonstrate anthropogenic enrichment by Cd, Ni, and Pb according to UCC, AWS, UCES, and FAO references, except for Ni, which shows depletion to minimal enrichment according to FAO.

- The mean I_{geo} values of HMs decreased in the following order: $Cd > Pb > Ni > Mn$. I_{geo} suggested that pollution due to Mn is negligible. Whereas the mean I_{geo} values for Cd, Ni, and Pb show severe to extreme pollution, moderate to severe pollution, and slightly to moderate pollution, respectively, according to UCC, AWS, and UCES standards. On the other hand, FAO standards indicated moderate pollution with Cd, slight pollution with Pb, and negligible pollution with Ni.

- HI values for adults were significantly lower than one, indicating no non-carcinogenic hazard. Conversely, the HI values for children were higher than one, indicating a non-carcinogenic hazard. TCR was more than acceptable range for both adults and children, suggesting significant carcinogenic health risks to adults and children in the study area.

II- Water samples

- The pH values of the main irrigation canals varied from 7.37 to 8.33. Nevertheless, drain samples had pH values ranging from 8.21 to 8.71. The EC_w values of the main irrigation canals varied from 0.49 ds/m to 2.90 ds/m, while drain samples had EC_w values ranging from 9.22 and 17.60 ds/m. The sequence of major cations (mmol/L) in irrigation water samples was Ca^{2+} (3.01) > Mg^{2+} (2.7) > Na^+ (1.29) > K^+ (0.77). While the sequence of main cations (mmol/L) in drain water samples was Na^+ (47.88) > Mg^{2+} (40.66) > Ca^{2+} (23.98) > K^+ (18.85). The sequence of major anions (mmol/L) was HCO_3^- (3.43) > Cl^- (3.19) > SO_4^{2-} (1.13) > CO_3^{2-} (0.00). While the sequence of main anions (mmol/L) in drain water samples was Cl^- (53.94) > SO_4^{2-} (48.33) > HCO_3^- (28.84) > CO_3^{2-} (0.00 mmol/L). SAR varied from 0.45 to 1.30 in the water samples from the main irrigation canals. Nevertheless, drain samples had SAR values ranging from 8.13 to 8.94.

- In general, the sequence of mean concentrations of HMs ($mg L^{-1}$) was: Mn (0.19) > Pb (0.10) > Ni (0.09) > Cd (0.02) in irrigation water samples and Pb (1.08) > Mn (0.86) > Ni (0.42) > Cd (0.07) in drain water samples.

- According to Law No. 48 of 1982, the mean CF_w values of HMs decreased in the following order: Pb > Cd > Ni > Mn. The Cd_w levels ranged between 1.90 and 184.24. Thus, most studied canals show high degree of contamination. On the other hand, the mean CF_w values of HMs according to FAO decreased in the following order: Cd > Mn > Ni > Pb. The Cd_w ranged between -2.87 and 9.56. Consequently, the main irrigation canals' beginnings were at a safe level, while most of their ends and El Bats water samples fluctuated between a medium and high degree of contamination.

- According to Law No. 48 of 1982, the mean EF_w values decreased in the following order: $Pb > Cd > Ni$. Otherwise, the mean EF_w values, according to FAO reference values, decreased in the following order: $Cd > Ni > Pb$.
- According to Law No. 48 of 1982, the MI ranged between 5.90 and 188.24. Thus, almost all selected stations are seriously threatened with metal pollution. MI results according to FAO's ranged between 1.13 and 13.56, which fluctuated between slightly, moderately, strongly, and seriously affected.
- HI values for both adults and children were within the safe limits, suggesting no obvious non-carcinogenic health risk. Most TCR values for the main irrigation canals and drains were between $1.00E-06$ and $1.00E-04$, indicating that the cancer risk is acceptable for both adults and children.

III- plant samples

- Generally, the order of mean metal concentrations in *Beta vulgaris* var. *altissima* samples was $Pb > Cd > Mn > Ni$ for shoot and root systems. The order of mean metal concentrations was $Pb > Ni > Mn > Cd$ in *Zea mays* and *Helianthus annuus* for shoot and root systems, and *Mangifera indica* leaves.
- Data for *Beta vulgaris* var. *altissima* and *Zea mays* showed that most of BCF and MR values are less than 1. Thus classifying this plant species into the category of nonaccumulating plants. On the other hand, the mean BCF and MR of *Helianthus annuus* indicated low metal translocation from soil to the plant parts in some sampling places and high translocation in other sites.

- TF for *Beta vulgaris* var. *altissima* was more than 1 for most of the collected samples, which means that it translocates metals effectively from root to shoot. Moreover, *Zea mays* translocate Cd and Pb (TF>1) effectively from root to shoot. On the other hand, TF of *Helianthus annuus* were less than 1. This finding showed minimal metal transfer from root to shoot in every sampling location.
- HI values from ingestion of *Beta vulgaris* var. *altissima* roots were less than one for both age groups, indicating that there is no significant risk of non-carcinogenic effects. The TCR for the edible part (root) of *Beta vulgaris* var. *altissima* lied in the range of $1.00E-06 < TCR < 1.00E-04$, demonstrating that the cancer risk may be acceptable.

Finally, the study highlights:

- (1) Preventing additional Cd and Pb contamination to improve the current condition in the Eastern regions of Fayoum government.
- (2) Conducting regular environmental monitoring procedures to assess the agricultural soil quality in the study region.
- (3) Children playing with surface soils should receive special attention.
- (4) Conducting routine medical examinations for adults and children.
- (5) There is no record of the national background amounts of heavy metals in Egyptian soils. As a result, more research is needed to determine Egyptian soils background values.

