An Investigation into Impact of Heavy Metals in Soil

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Abstract
The aim of this paper is to assess the environmental risks associated with the wastewater reuse with respect to six metals; cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb) and zinc (Zn) in the city of Dubai. Treated Sewage Effluent (TSE) is used for landscape irrigation. Samples of soil and control soil as baseline measurement were collected to calculate the contamination factor (CF), pollution load index (PLI), metal pollution index (MPI), degree of contamination (CD) and modified degree of contamination (mCD) of heavy metals in soil. The results revealed that the values of the CF were very high, the PLI and MPI were high, the CD was very high, and the mCD was ultra-high.
Keywords: Soil Pollution, Contamination Factor, Pollution Load Index, Metal Pollution Load Index, Degree of Contamination

1. Introduction

Long term use of treated wastewater in irrigation can lead to accumulation of some heavy metals in the treated soil. This study aims to assess the environmetnal reisk associated with the long term use of treated wastewater some metals in the soil. The metals incluced in this study were Cadmium, Chromium, Copper, Nickel, Lead and Zinc.

2. Methodology

In this research, samples from control soils (background soil) as well as treated soils have been collected and analyzed. for Cd, Cr, Cu, Ni, Pd, and Zn. The results of the analysis were then used as a basis for calculations. Soil samples were collected from preselected areas of Dubai classified into three categories of Remote Dubai (1978-1988), Intermediate Dubai (1989-2008) and Recent Dubai (2009-2016) to obtain the current situation of the heavy metal contamination of soil. The results were then used to assess and calculate the environmental risks. The environmental risk has been computed through a set of parameters such as contamination Factor (CF) (Hakanson 1980), Pollution load index (PLI) (Tomlinson et al. 1980), and Metal Pollution Index (MPI) using equations 1, 2, and 3 respectively.

$$CF = = \frac{C_m}{C_{Background}} \quad \text{..... (1)}$$

where Cm is the concentration of the examined element in the soil sample in mg/kg, and $C_{Background}$ is the concentration of the examined element in the background soil. Values less than 1 refer to low CF, and CF values higher than 6 are considered as very high CF.

$$PLI = \sqrt[n]{CF_1 \times CF_2 \times \ldots \times CF_n} \quad \text{..... (2)}$$

where n is the number of examined elements in the soil sample, and CF is the contamination factor.

$$MPI = \sqrt[n]{CF_{i1} \times CF_{i2} \times CF_{i3} \times CF_{i4} \ldots \times CF_{in}} \quad \text{.....(3)}$$

where
CFi1 is the CF of element i in Sector 1,
CFi2 is the CF of element i in Sector 2,
CFin is the CF of element i in Sector n, and
n is the number of sectors in which the CF of element i is calculated.

The degree of contamination (CD) and modified degree of contamination (mcD) were calculated using equation 4 and 5 respectively.

$$CD = \sum_i^n CF_i \quad \text{..... (4)}$$

where CFi is the CF of element i

$$mCD = \frac{\sum_i^n CF_i}{n} \quad \text{..... (5)}$$

Where CFi is the CF of element i and n is the number of CF values obtained.
Table shows the value ranges of mCD and their classification (Abrahim & Parker 2008).

2.6 Statistical Analysis

The means from each sector were compared through Kruskal-Wallis H test (with Bonferroni correction for multiple tests) because ANOVA assumptions were violated.
variance between the groups (which was tested by Levene's test).

3. Results and Analysis

The results of the mean comparisons for all 6 metals across the different sectors in Dubai (Remote, Intermediate and Recent) are shown in Table 2. The results reveal that there was a statistically significant difference at the $p<0.05$ level between the three locations with regards to the heavy metals Copper ($X2(2,17)=11.80$, $p=0.003$), Nickel ($F(2,17)=3.71$, $p=0.049$) and Lead ($X2(2,17)=9.998$, $p=0.007$)

Table 1. *mCD values and their classification*

mCD value	Classification
mCD<1.5	No to very low CD
1.5≤mCD<2	Low CD
2≤mCD<4	Moderate CD
4≤mCD<8	High CD
8≤mCD<16	Very high CD
16≤mCD<32	Extremely high CD
mCD≥32	Ultrahigh CD

Table 2. *Comparison of the means for Contamination Factor in Soil for Six Heavy Metals between Remote Dubai, Intermediate Dubai and Recent Dubai*

	Remote Dubai (N=6)	Intermediate Dubai (N=5)	Recent Dubai (N=7)	Test of Significance
Cadmium Contamination Factor	89.4±22.3	75.3±17.4	75.3±16.04	$F_{(2,17)}=1.105$ (a) P=0.357
Chromium Contamination Factor	7597±1567	6953±1063	7775±2264	$F_{(2,17)}=0.328$ (a) P=0.725
Copper Contamination Factor	10269±4013	9816±6045	5832±470	$X^2_{(2,17)}=11.80$ (b) P=0.003
Nickel Contamination Factor	5515±605	5268±1199	4267±808	$F_{(2,17)}=3.71$ (a) P=0.049
Lead Contamination Factor	750±383	260±106	186±66.4	$X^2_{(2,17)}=9.998$ (b) P=0.007
Zink Contamination Factor	4241±2738	3868±1404	2570±1244	$X^2_{(2,17)}=2.555$ (b) P=0.279

4. Conclusion

The CF values obtained revealed that all six studied elements have CF values exceeding the highest CF classifications specified in Table 1. the PLI values for all heavy metals exceeded 1, which, per the classification in Table 2, is considered "polluted". The results reveal that all MPI values of the six elements exceeded the MPI classification of 1, per Table 2, meaning they are all classified as polluted. All values of the CD and mCD suggest a very high and ultra-high CD, respectively, per the classification values for the degree and mCD. The PLI values in all sectors exceeded 1, which, per the PLI classification, is considered "polluted". Overall, the CD and mCD results for all the Dubai sectors revealed a very high and ultra-high CD, respectively.

5. Recommendation

Long-term reuse of treated wastewater can lead to the accumulation of different metals in the soil. This should be considered in future planning by enacting more guidelines for wastewater treatment plants and use more advanced technologies. On the other hand, regulating household chemicals can reduce the possibility of long-term accumulation of metals in soil at source.

References

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