Soil Pollution Assessment in Agricultural Drainage Canals in Southern Kirkuk Governorate, Iraq

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Abstract

This study Conducted to assess the level of heavy metal pollution in the soil of agricultural drainage canals located in southern Kirkuk Governorate .Twenty three soil samples taken from the soil with the control sample nearby the two canals (A,B) in (0-30) cm depth. Laboratory analyses were conducted to determine the concentrations of heavy metals, namely iron (Fe), lead (Pb), nickel (Ni), cadmium (Cd), zinc (Zn), and manganese (Mn) and to determine the degree of pollution using the pollution factor (CF). The results showed the iron contamination factor values varied between 0.497 to 0.770 for the drainage (A), while drainage (B) values varied between 0.497 to 0.905 representing low pollution and manganese contamination factor values varied between0.264 to 0.276 for the drainage (A) while drainage (B) values varied between 0.267 to 0.278 representing low pollution, and the lead was contamination factor values varied between 0.264 to 0.276 for the drainage (A) while drainage (B) vales varied 0.267 to 0.278 classified as having low pollution. Zinc contamination factor values varied between 0.666 to 1.200 for the drainage(A) while drainage (B) values varied between 0.876 to 1.258 representing low to moderate contamination , while nickel contamination factor values varied 0.735 to 6.539 for the drainage (A) while drainage (B) values varied between 0.950 to 1.115,and showed cadmium contamination factor values varied between 0.000 to 6.363 for the drainage (A) while drainage(B) values varied between 0.000 to 4.545. Cadmium was found to have the highest pollution levels compared to the other elements, with values ranging from moderate to high to very high, indicating the impact of ongoing agricultural activities and the use of chemical fertilizers and pesticides. Spatial distribution maps revealed variations in the spread of heavy metals within the drains due to the influence of drainage water and local soil characteristics.

Keywords: Agricultural pollution, Drain, Pollution factor, Heavy metals, Kirkuk, Iraq.

Introduction

Soil pollution affects soil fertility, thus reducing agricultural crop production. The impact of pollution is not limited to plants but even more to humans and animals. This pollution occurs as a result of human activities such as industrial extraction, the use of fertilizers and pesticides, and the release of industrial waste. Heavy metals can accumulate in the soil and affect plants and animals. Agricultural pesticides, in their various types and for their multiple uses, consist of organic and inorganic compounds and contain varying proportions of heavy metals. Due to the excessive and prolonged use of these types of pesticides, they have contributed to soil pollution with heavy metals, including in agricultural drainage systems. [1]studied the environmental impact of dumping industrial water pollutants into an agricultural drain in Menoufia, Egypt, on soil and plants. The water analysis results showed that heavy metals exceeded the permissible limit according to the WHO.[2]studied heavy metal pollution of canal soil in the Damwar Basin in India, where the pollution factor (CF) was determined. The CF value was found to be

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moderate, but the geological accumulation showed moderate pollution. [3]conducted a study of heavy metal pollution of water catchment soils, their distribution, and sources in an agricultural canal, using various pollution indicators. The catchment areas ranged from moderately polluted to unpolluted. [4]studied the dumping of materials from various sources and their indirect and direct effects on some chemical and physical properties of drainage water in Karbala Governorate, which affected the quantity and properties of the water.[5] studied the pollution of agricultural soil located between the Al-Kifl stream and the Awfi River. The study indicated that the soil in the study area was not contaminated, and if any contamination was present, it was within permissible limits. [6]studied the water quality of the Diyala River in relation to heavy metal contamination of agricultural soils adjacent to the river. The results showed variations in the chemical properties of the water and soils studied during the winter and summer seasons.

The aim of this research is to assess the contamination of the soil of two agricultural drains located in the southern part of Kirkuk governorate with heavy metals.

Study area

The agricultural drains are located in the Daquq District of Kirkuk Governorate, between the villages of Yankajah and Abdullah Ghanem in the northeastern part of Iraq. The study area extends between latitudes 35°14'265"N and 35°14'255"N and longitudes 44°39'771"E and 44°39'745"E, approximately 42 km south of Kirkuk city, based on the measurements taken. Using a GPS device, Fig. 1 shows the study area.



Drainage Canal(A) Drainage Canal(B)

Fig 1.The study area.

Material and Methods

Soil Sample Collection: twenty three (23) soil samples were taken from the surface layer in the drainage canals A and B. Nine samples were taken from drain A and twelve from drain B, along with a control sample for both drains. The depth of the samples was 0-30 cm. The locations were determined using a GPS device. The samples were then transported to the Soil Science and Water Resources Laboratories, College of Agriculture, Kirkuk University, for analysis of heavy metals such as iron, lead, cadmium, zinc, nickel, and manganese. And it was done using Nitric acid at a concentration of 69% was added by adding (20)ml parts of the acid to1gram of soil samples, and after 15 minutes perchloric acid was added (10)ml concentration (70%)then the soil samples were heated until the sediment farmed from the soil disappeared. After that ,the extract filter paper was moistened and added (100)ml from distilled water the heavy elements were then estimated using a device atomic absorption spectrometer according to what was stated[7].

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Calculation of the Contamination Factor (CF): The study involves using this factor which is calculated to determine the difference between contaminated and uncontaminated soil and the percentage of soil contamination in the two drains. It is called the anthropogenic factor because it results from human activities [8]

CF = Cm Sample / Cm Background

Where:

Cm Sample: Concentration of the pollutant in the soil sample (mg kg^{-1})

Cm Background: Concentration of the element in the reference sample (mg kg^{-1})

Results and Discussion

Iron Pollution Factor (CF)

This factor represents the total concentration of the heavy metal in the soil compared to the concentration of the heavy metal in unpolluted soil and is measured in ppm. It indicates the impact of human activity on the pollution level.

The results of the study, shown in (Table 1), indicate that the CF (Contamination Factor) values varied between 0.770 and 0.497 for drain (A). The highest CF value was recorded in sample 3 (0.770), while the lowest was in sample 2 (0.497), with an overall average of 0.576. The CF value for iron in the control sample was 0.682. In drain (B), the CF values for iron varied between 0.905 and 0.496. The highest CF value was recorded in sample 16 (0.905), while the lowest was in sample 20 (0.496), with an overall average of 0.665. The CF value in the control sample was 0.662. The soil in both drains (A and B) in all samples falls under the low pollution category, as do the two control samples, according to (Table 2)

The results of the study shown in Fig 2 showed the spatial distribution map of the iron pollution factor for drain (A). It increases in a part on the western side and decreases in all other parts of the drain. The values of the comparison sample were higher than all samples except for sample (3). The reason for this is due to the washing process to which the soil is exposed by the drain water. As for drain (B), it increases in a part on the western side of the drain and decreases in other parts. The comparison sample was higher than all samples except for samples 10, 12, 13, 14, 16, 17, and 18. The reason for this is due to the washing process of the soil by the drain water. This is consistent with what was concluded by [9].

Table(1)The results of measured heavy metal pollution factor(CF) [10][11]

Sample no	CF					
	Mn	Zn	Cd	Ni	Pb	Fe
1	0.270	0.776	6.363	0.813	0.000	0.561
2	0.265	0.693	6.363	0.949	0.041	0.497
3	0.275	1.200	2.727	1.037	0.034	0.770
4	0.264	0.666	0.000	0.735	0.000	0.508
5	0.271	0.918	0.000	1.060	0.096	0.596
6	0.271	0.871	5.454	0.962	0.000	0.575
7	0.276	1.090	0.000	0.908	0.113	0.602
8	0.271	0.806	1.818	0.844	0.100	0.561
9	0.271	0.788	0.000	6.539	0.048	0.516
Average A	0.270	0.867	2.525	1.538	0.048	0.576

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Control A	0.257	1.445	10.909	0.853	0.548	0.682
Min A	0.264	0.666	0.000	0.735	0.000	0.497
Max A	0.276	1.200	6.363	6.539	0.113	0.770
10	0.274	0.953	2.727	1.092	0.041	0.675
11	0.274	1.121	0.000	0.862	0.103	0.626
12	0.272	0.956	1.818	0.997	0.075	0.663
13	0.278	1.258	4.545	1.047	0.210	0.730
14	0.276	1.246	0.000	1.096	0.262	0.673
15	0.267	1.210	3.636	0.950	0.072	0.588
16	0.275	1.168	2.727	1.095	0.096	0.905
17	0.277	1.238	1.818	1.068	0.055	0.680
18	0.273	1.241	2.727	1.115	0.206	0.678
19	0.268	1.181	1.818	0.996	0.113	0.645
20	0.269	0.876	2.727	0.787	0.196	0.496
21	0.272	1.016	0.000	0.950	0.131	0.618
Average B	0.272	1.122	2.045	1.004	0.130	0.665
Control B	0.273	1.290	6.363	1.006	0.220	0.662
Min B	0.267	0.876	0.000	0.950	0.041	0.496
Max B	0.278	1.258	4.545	1.115	0.262	0.905
Background	857.3378	60	0.11	100	29	40439.57

Table(2) The pollution factor degree.[8]

Degree	CF
Low pollution	1 < CF
Moderate pollution	3 < CF ≤ 1
High pollution	6 < CF ≤ 3
Very high pollution	6 ≥ CF

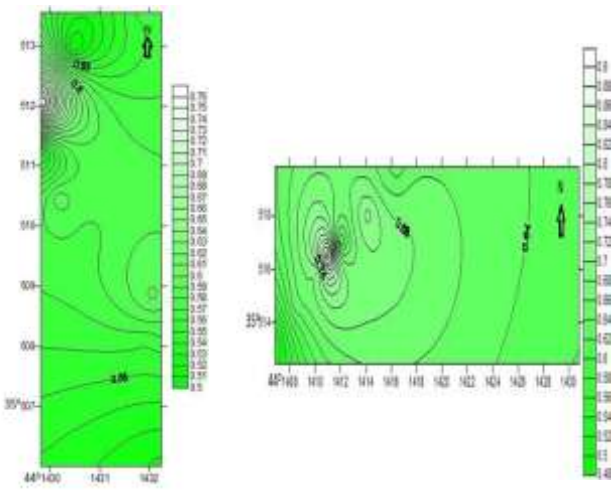


Fig 2.Geospatial map of iron (CF) for two drains (A&B).

Lead Pollution Factor (CF)

The results of the study, shown in (Table 1), indicate that the values of the lead pollution factor (CF) index varied between (0.000-0.113) for drain (A). The highest value of the lead pollution factor index was recorded in sample 7, reaching (0.113), and the lowest value was recorded in samples 1, 4, and 6, reaching (0.000), with an overall average of (0.048). The value of the lead pollution factor index in the control sample was (0.548). As for drain (B), the values of the lead pollution factor index varied between (0.041-0.262). The highest value of the pollution factor index

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was recorded in sample 14, reaching (0.262), and the lowest value was recorded in sample 10, reaching (0.041), with an overall average of (0.130). The value of the lead pollution factor index in the control sample was (0.220). The study revealed that the lead pollution factor values fell within the low pollution category in all samples for drains (A and B). When compared to the control sample, the control sample had a higher value, but it also fell within the low pollution category, as shown in (Table 2).

The results of the study, as shown in Fig .3, demonstrate the spatial distribution of the lead pollution factor for drain (A). The concentration increased in the southeastern part of the drain and decreased in the northern part, with the control sample having the highest value. For drain (B), the lead pollution factor increased in the northwestern part of the drain and decreased in the eastern and southeastern parts. The control sample also had the highest value, except for sample 14. This difference is attributed to soil leaching by the drain water.

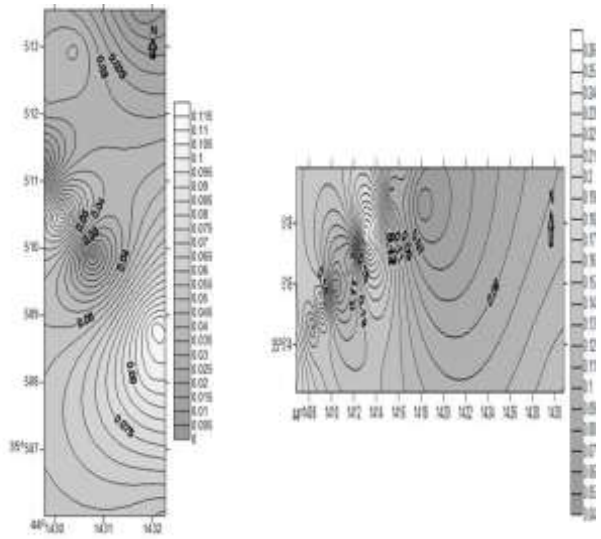


Fig. Geospatial map of lead (CF) for two drains (A&B)

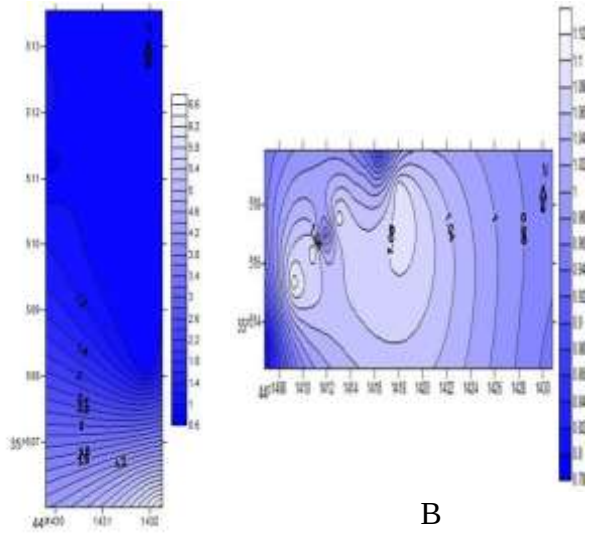
Nickel pollution factor (CF)

The results of the study shown in (Table 1) indicate that the values of the pollution factor (CF) index for the nickel element varied between (0.735-6.539) for the drain (A), where the highest value of the pollution factor index for the nickel element was recorded in sample 9, where it reached (6.539), and the lowest value of the pollution factor index for the nickel element was in sample 4, where it reached (0.735), and the general average was (1.538), and the value of the pollution factor index for the nickel element was (0.853) in the comparison sample. As for the drain (B), the values of the pollution factor for the nickel element varied between (0.950-1.115), where the highest value of the pollution factor for the nickel element was recorded in sample 18, where it reached (1.115), and the lowest value of the pollution factor index for the nickel element was in samples 15,21, where it reached (0.950), and the general average was (1.004). The pollution factor index for nickel in the control sample was 1.006. Table(2)shows that the pollution factor values for nickel in drain A fall under the low pollution category, with the exception of samples 3 and 5, which fall under the medium pollution category, and sample 9, which falls under the very high pollution category. The pollution factor value in the control sample also falls under the low pollution category. In drain B, the pollution factor falls under the low pollution category, except for samples 10, 13, 14, 16, 17, and 18, which fall under the medium pollution category. The pollution factor value for nickel in the control sample falls under the medium pollution category, which contradicts the findings of [9].

The results of the study shown in Figure (4) showed the spatial distribution of the nickel pollution factor for drain (A). It increases in the southeastern part and decreases in all other parts of the drain. The percentage of the nickel pollution

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factor in all samples was higher than the control sample except for samples 1, 4, and 8 of drain (A). As for drain (B), the nickel pollution factor was increasing in the middle of the drain and extending to the west, and it decreased in the eastern and southwestern parts. All samples were higher than the control sample except for samples 11, 12, 15, 19, 20, and 21. This is also due to the addition of fertilizers and pesticides to the soil.



B

Fig 4. Geospatial map of Nickel (CF) for two drains (A&B)

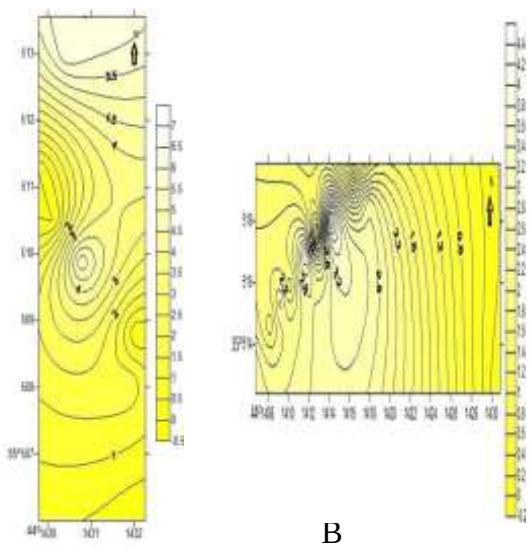
Cadmium pollution factor Cd (CF)

The results of the study, shown in (Table 1), indicate that the values of the cadmium pollution factor varied between (0.000 - 6.363) for drain (A). The highest value of the cadmium pollution factor index was recorded in samples 1 and 2, reaching (6.363), while the lowest value was recorded in samples 4, 5, 7, and 9, reaching (0), with an overall average of (2.525). The value of the cadmium pollution factor in the control sample was (10.909). Meanwhile, the values of the cadmium pollution factor index for drain (B) varied between (0.000 - 4.545). The highest value of the pollution factor index was recorded in sample 13, reaching (4.545), while the lowest value was recorded in samples 11, 14, and 21, reaching (0.000), with an overall average of (2.045). Cadmium pollution in a control sample (6.363). The results, as shown in (Table 2), indicate that the cadmium pollution factor value in samples 1 and 2 of drain (A) falls within the very high pollution category, while samples 3 and 8 fall within the medium pollution category, and sample 6 falls within the high pollution category. Samples 4, 5, 7, and 9 fall within the low pollution category, and the control sample also falls within the very high pollution category. Most of the results for the pollution factor index in drain (B) fall within the medium pollution category, except for samples 11, 14, and 21, which fall within the low pollution category. Samples 13 and 15 fall within the high pollution category, and the control sample falls within the very high pollution category. The soil of drain (A) falls within the medium to high pollution category, while the control sample falls within the very high pollution category. This is attributed to the soil's exposure to continuous leaching by drain water. Drain (B) falls within the high pollution category, while the control sample falls within the very

high pollution category.

The results of the study, shown in Fig.5 indicate that the spatial distribution of the cadmium pollution factor for drain (A) increases in the northern and central parts of the drain and decreases in the southern part. As for drain (B), the percentage of the cadmium pollution factor increases in the central and western parts of the drain and decreases in the other parts of the drain.

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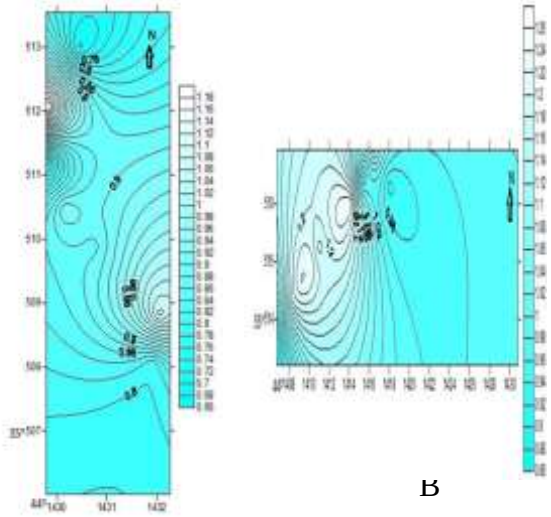
B

Fig 5.Geospatial map of Cadmium(CF)for two drains (A&B).

Zinc Pollution Factor Zn (CF)

The results of the study, shown in (Table 1), indicate that the values of the zinc pollution factor index varied between (0.666-1.200), with the highest value of the zinc pollution factor index recorded in sample 3, which reached (1.200), and the lowest value of the zinc pollution factor index was in sample (4), which reached (0.666), and the overall average was (0.867). The value of the zinc pollution factor index in the comparison sample was (1.445). Meanwhile, the values of the zinc pollution factor index for the drain (B) varied between (0.876-1.258), with the highest value of the zinc pollution factor index recorded in sample 13, which reached (1.258), and the lowest value of the zinc pollution factor index was in sample 20, which reached (0.876), and the overall average was (1.122). The value of the zinc pollution factor index in the comparison sample was 1.290. Most soil samples from drain (A) fall under the low pollution category, with the exception of samples 3 and 7, as shown in(Table 2). The control sample falls under the medium pollution category. Soil samples from drain (B) fall under the medium pollution category, except for samples 10, 12, and 20, which fall under the low pollution category. The control sample falls under the medium pollution category. This is not consistent with[5].

The study results, shown in Fig.6, illustrate the spatial distribution of zinc pollution in drain (A). The pollution factor increases in the central part of the drain and decreases in other parts. The percentage in the control sample was higher than all other samples, which is attributed to soil leaching by drain water. In drain (B), the zinc pollution factor increases in the western parts of the drain and decreases in the eastern parts. The pollution factor percentage in all samples was higher than the control sample, except for samples 10, 12, 15, and 20. This may be due to the addition of fertilizers and pesticides.



B

Fig 5.Geospatial map of Zinc (CF)for two drains (A&B).

Manganese Pollution Factor (Mn) (CF)

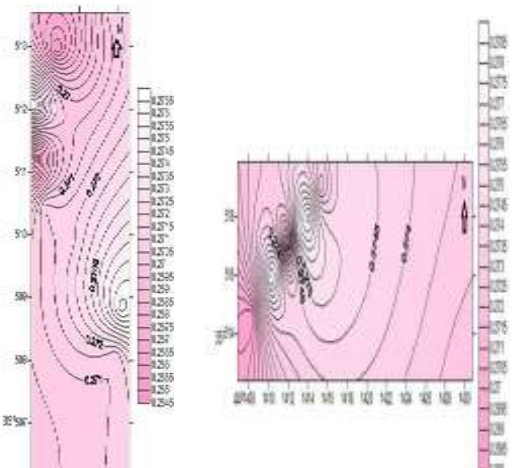
The results of the study, shown in (Table 1), indicate that the values of the manganese pollution factor index for drain (A) varied between (0.264 – 0.276). The highest value of the manganese pollution factor index was recorded in sample 7,

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reaching (0.276), while the lowest value was in sample 4, reaching (2.644), with an overall average of (0.270). The value of the manganese pollution factor index in the control sample was (0.257). Meanwhile, the values of the manganese pollution factor index for drain (B) varied between (0.267-0.278). The highest value of the manganese pollution factor index was recorded in sample 13, reaching (0.278), while the lowest value was in sample 15, reaching (0.267), with an overall average of (0.270). The manganese pollution index in the control sample was (0.272), and the value of the manganese pollution factor index in the control sample was (0.273).

The soil of drains (A and B) falls within the low pollution category, according to (Table 2). The control sample for both drains is also classified as low pollution, which is consistent with the findings of [9].

The results of the study, shown in Fig.7, indicate the spatial distribution of the manganese pollution factor in drain (A). It increases in the central section on the eastern side of the drain and decreases in the northern section. The percentage of all samples was higher than that of the control sample, which may be attributed to the addition of fertilizers and pesticides. As for drain (B), the manganese pollution factor increases in the central and western sections of the drain and decreases in the eastern sections. The percentage of all samples was higher than that of the control sample, except for samples 12, 15, 19, 20, and 21.



A B

Fig7.Geospatial map of Manganese (CF)for two drains (A&B).

Conclusion

This study aimed to assess the level of heavy metal pollution in two agricultural drainage canals located south of Kirkuk Governorate, Iraq, within the Daquq District. This was achieved through the analysis of 23 surface soil samples and their comparison with reference samples. The study included estimating the concentrations of heavy metals, namely iron, lead, nickel, cadmium, zinc, and manganese, and employing the pollution factor (CF) to determine the degree of pollution for each element. The results showed that iron, lead, and manganese were at low pollution levels in most samples, while zinc exhibited levels ranging from low to moderate pollution. Nickel showed moderate pollution in some locations and very high pollution in one sample, indicating the impact of agricultural activities and the use of fertilizers and pesticides. Cadmium was found to be the most hazardous element, recording high to very high pollution levels in several samples, reflecting the likelihood of its accumulation due to ongoing agricultural practices. Spatial distribution maps revealed a clear variation in the spread of heavy metals within the study area, depending on soil characteristics and the influence of drainage water. The study's findings

underscore the importance of continuous environmental monitoring of agricultural drainage soils and taking necessary measures to reduce the accumulation of heavy metals and maintain soil quality and agricultural production.

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