

Analysis of the Groundwater and Soil Pollution by Oil Leakage

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Abstract

Oil is one of primary energy sources in modern society, with the development of social economy, the demands of the oil have increased dramatically. However, various oil leakage accidents occur frequently which can cause serious pollution to soil and groundwater, these have become nonnegligible environmental problems. Based on the accident of diesel leakage in Weinan branch of LanZhengChang oil product pipeline, this article analyzes the pollution degree and range of groundwater and soil using Kriging interpolation method, the results indicate that the groundwater and soil pollution is serious and there is no influence on Chishui River after kinds of measures, finally the article puts forward some corresponding countermeasures.

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Keywords: Oil leakage; Pollution; Groundwater; Soil

1. Introduction

Oil is one of primary energy sources in modern society, with the development of social economy, the demands of the oil increase dramatically. However during the exploration, mining, storage, transportation and use of the oil products, various oil leakage accidents occurred frequently which may cause serious pollution to soil and groundwater. Due to the characteristics of strong concealment, long latency, wide range, and difficulty in treatment, the harm of oil leakage has already become a nonnegligible environmental problem[1,2,3].

LanZhengChang oil product pipeline, the largest domestic oil product pipeline project at present, is one of the significant measures of Western Development strategy implemented by State Council. In the early morning on December 30th, 2009, diesel leakage accident took place in Weinan branch of LanZhengChang oil product pipeline of PetroChina Company, which caused surface water pollution due to diesel drainage into the Chishui River and Wei River. After the incident, emergency plan was started and kinds of measures were carried out immediately, such as plugging leakage point, cleaning up the

contaminated soil and setting oil separation barrier in the lower reaches of Chishui River and Wei River which have controlled the pollution of the surface water efficiently. But the pollution to the groundwater and soil was unclear. In the paper, the pollution to groundwater and soil caused by oil leakage is analyzed and corresponding security measures are put forward.

2. General Situation

The leakage point is located in the channel of Chishui River, 550 m northwest of Chishui town in Weinan City. The pipeline is buried 6m below the surface and 2m above the water table, and about 3km apart from Wei River.

The leakage field is located in the first terrace of Wei River with high terrain in the south and low terrain in the north and slope of 1.74%. The lithology is mainly Quaternary alluvium with loess layer above. The groundwater level is usually 4~6m and flows from south to north. The precipitation infiltration, the agricultural irrigation infiltration and lateral runoff supply in the south are the main sources of the groundwater recharge. And the main discharges are groundwater evaporation and discharge to the Wei River.

In order to take soil samples and groundwater samples around the leakage point and make further analysis of the contamination degree of soil and groundwater, 15 boreholes were drilled. The water samples include surface water samples and groundwater samples, and the former were taken not only in the boreholes but also in the wells within the range of 2km around the leakage point, the later were taken in the upper and lower reaches of Chishui River and beside the leakage point. The soil samples were taken in the boreholes by the interval of 1~2m. The total water samples collected are 36 and soil samples collected are 131.

3. Analysis of Groundwater Pollution

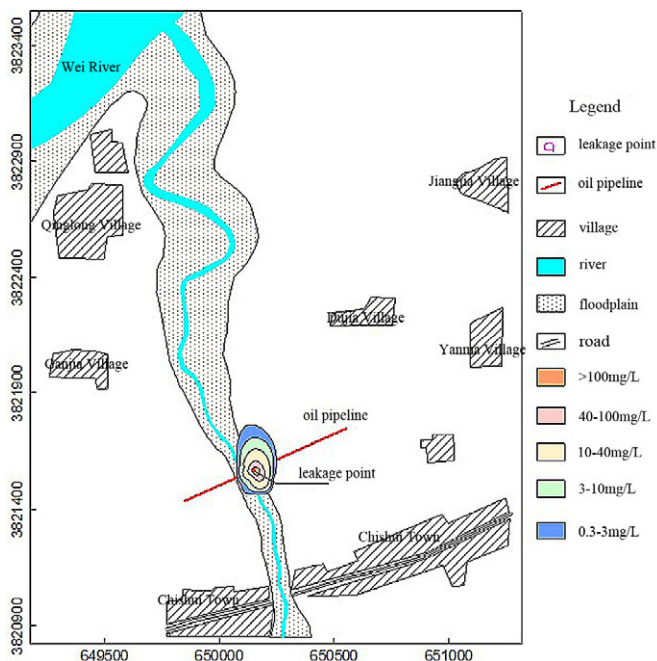


Figure 1 Zone map of pollution range for groundwater

The groundwater flows from south to north in the survey area on the whole, the contaminants spread with the flow and mainly migrate to the lower reaches. Based on the measured concentration value of petroleum pollutants from 36 water samples, Kriging interpolation method[4] is adopted to divide the groundwater pollution area into 5 areas which is shown in Figure 1.

It can be seen from Figure 1 that the petroleum pollution range of the groundwater is 116m to the south, 195m to the north, 74m to the west and 95m to the east around the leakage point, the total pollution area is 43118m². The pollution areas with petroleum pollutants concentration more than 100mg/l, 40~100mg/l, 10~40mg/l, 3~10mg/l and 0.3~3mg/l are respectively 878m², 3540m², 11021m², 12973m² and 14706m², and the corresponding percentages are respectively 2% , 8%, 26%, 30% and 34% of the total pollution area.

According to “the Standard for Drinking Water Quality” (GB5749-2006) [5, 6], the maximum concentration of petroleum pollutants in drinking water is 0.3 mg/L. Based on the above statistic results, within the range of 28412m² around the leakage point, the concentration is more than 3mg/l, which means in 66% of the total area, the ratio of concentration of pollutions to the maximum value is more than 10. Among them, the areas with the ratio of 133~330, 33~133, 10~33 are respectively 3540m², 11021m², 12973m². It can be concluded the pollution degree of the groundwater is serious.

4. Analysis of Soil Pollution

By the leakage point, due to the high pressure in the oil pipeline, the diesel diffused in the soil in unsaturated zone and caused the soil polluted. With the pollution range expanding, the pressure become smaller, soil pollution is mainly caused by pollutants migrating with the flow of groundwater. The diesel density is smaller than water density which caused the diesel to float on top of groundwater, under this case, the pollution of soil mainly occurred around the water table. Soil pollution is analyzed in this article from two conditions of plane and section respectively.

4.1 Plane Pollution

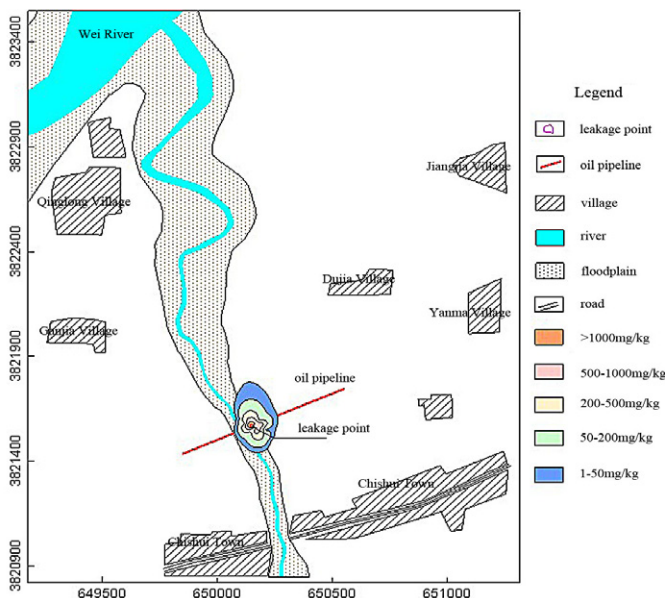


Figure 2 Zone map of pollution range for soil

Based on the measured results of petroleum pollutants concentration from 17 soil samples near the water table, Kriging interpolation method is adopted to divide the soil pollution area into 5 areas which is shown in Figure 2.

It can be seen from Figure 2 that the petroleum pollution range of the soil is 133m to the south, 209 to the north, 70m to the west and 119m to the east around the leakage point, the total pollution area is 48076m², and the pollution range in the soil is basically similar to the one in the groundwater. The pollution areas with petroleum pollutants concentration values more than 1000mg/kg, 500~1000mg/kg, 200~500mg/kg, 50~200mg/kg and 1~50mg/kg are respectively 672m², 2876m², 6230m², 16418m² and 21880m² and the corresponding percentages are respectively 1%, 6%, 136%, 34% and 46% of the total pollution area.

From the pollution degree, the area in which the concentration is more than 50mg/kg takes 54% of the total pollution area, it can be concluded the soil pollution is also serious.

4.2 Section Pollution

According to the analyzed results of soil samples from different levels in the boreholes, the section drawings are drawn along east-west direction with boreholes of ZK03、WR、ZK12 and south-north direction with boreholes of ZK08、ZK09、WR、ZK10、ZK11.

It can be seen from the two figures that the soil pollution rang above the water table is mainly concentrated within the range of 40m around the leakage point, the pollutant concentration reaches the maximum in the leakage point, and declines along both sides. In Figure 4, the measured soil concentration under the surface of 1~2m in borehole ZK09、ZK10、ZK11 is higher, this is mainly caused by excavated soil stacking and the pollutants moving down after the accident.

5. Analysis of Chishui River Pollution

During this investigation, the surface water samples in Chishui River are also analyzed. The samples were collected in the upper reaches with a distance of 150m (S19) from the leakage point, lower reaches with a distance of 1200m (S08) from the leakage point, and flank of the leakage point (S09). Based on the analyzed results, the petroleum pollutants were not detected in the three samples which indicate the leaked diesel has no influence on the river after kinds of measures.

6. Conclusions

According to analysis of measured results of water and soil samples, the following conclusions can be drawn.

(1) The pollution area of the groundwater and soil is 133m to the south, 209m to the north, 119m to the east and 74m to the west around the leakage point. The groundwater pollution range is 43118m², and the soil pollution range is 48076m².

(2) Above the water table, the soil pollution range is 40m around the leakage point. Beyond the range, the pollution mainly takes place around the water table.

(3) Based on the analyzed results of Chuishui River (the upper reaches with a distance of 150m, flank of the leakage point, lower reaches with a distance of 1200m), the petroleum pollutants are not detected in the three samples after kinds of measures which indicates the leaked diesel has no influence on the river.

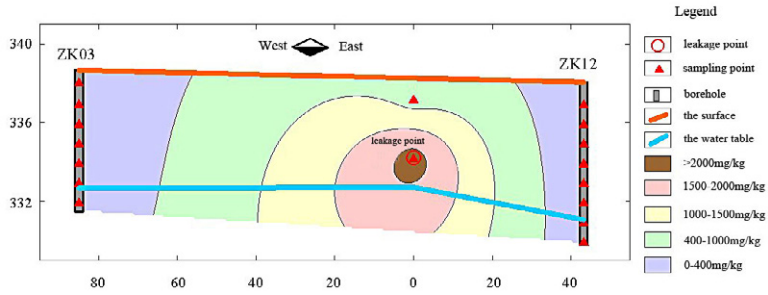


Figure 3 Sectional drawing along east-west direction

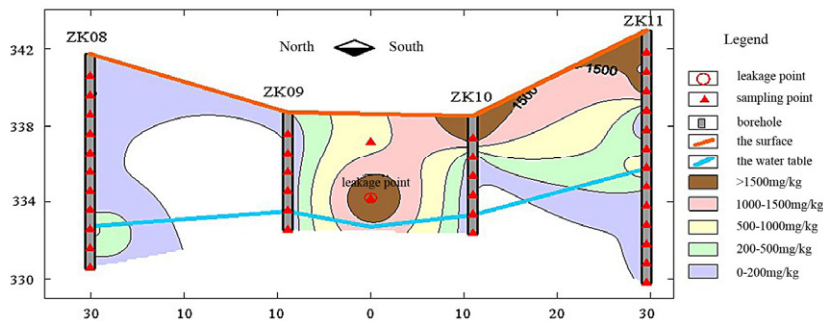


Figure 4 Sectional drawing along north-south direction

7. Suggestions

(1) The groundwater is in the state of constant movement, the petroleum pollutants migrate continually with the flow, in the meantime, the volatilization, adsorption and degradation of pollutants occur. Therefore, pollution range expanded and the concentration change constantly with time in the groundwater. In view of this, the further research on the status of contamination migration is suggested, by establishing a mathematical model, the range and degree of pollutants in the survey area can be predicted dynamically and treatment measures can be taken timely.

(2) The severely polluted groundwater should be promptly extracted and managed to avoid the further expansion, the severely polluted soil should be repaired or removed and filled with no pollution soil timely[7].

(3) It is suggested that pollution surveillance work should be done well, especially the surveillance on groundwater of Qinglong village, Sanzhang village and Zhanjia village, sampling and monitoring regularly is needed to ensure the safety of drinking water in the lower reaches.

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