Examination of Route of Oil Migration and Screen the Source of Oil Contamination in External Wells near a Factory

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ABSTRACT:The paper presents an investigation carried out to screen the source of oil contamination and to trace route of migration over a suspected leak of diesel from a supply line in tyre manufacturing factory in Matara, in 2012. The incident was noted in 2012 where several people in the surrounding area complained of kerosene like smell in drinking water obtained from their wells. The company engaged NBRO to investigate and report the matter and the investigations were based on most suspected sources of oil and paths responsible for contamination of water in wells. The investigations were directed on two hypotheses ;i) Adding of kerosene to wells purposely with the intention of obtaining compensation, ii) Contamination from leaking diesel oil pipeline from the factory. Methodologies were focused on site screening, physical and chemical analysis of water and soil in suspected contaminated sites. The factory oil installations and pipelines were inspected along with factory engineers to trace possible leaks. The route of oil migration path was traced by borrowing test pits at most suspected routes up to the depth of water table. At the site inspection a leak in the diesel pipeline was noted and oil was traced in soils and ground water near the spills. The detected oil levels showed that the contaminants were moving along the slope land in the direction where neighboring wells were located. The lab test on density confirmed that the contaminated oil source is diesel and not kerosene. All wells tested were confirmed with diesel oil, contaminated with oil exceeding the maximum permissible level for potable water given in the Sri Lanka Standards. The findings further confirmed that oil has been leaking and contaminating the groundwater for a long period and migrating at the soil-water interphase in deeper soil layers along the sloping direction.Upon confirmation, the company initiated immediate measure to pump out ground water and excavate contaminated soils from the site.

1 INTRODUCTION

The study is based on a work carried out to screen the source of oil contamination and to trace its route of migration over a suspected leak from a supply line in a Tyre manufacturing factory in Matara. The incident was noted in 2012 where several people in the surrounding area complained of kerosene like smell in the water. The main source of drinking water in the area is ground water. Over public protest the company requested National Building Research Organisation (NBRO) to investigate and report the matter, and the investigations were based on most suspected sources of oil and paths responsible for contamination of water in wells. The investigations were directed on two hypotheses (i) purposeful adding of kerosene to wells with the intention of obtaining compensation or (ii) migration of oil from a leaking diesel oil pipeline from the factory.

METHOD

To investigate the problem of contamination in well water in the neighborhood, the methodology was focused on;

i. Site inspection: Site inspection was carried out to detect sources of contamination, and the topography of the land and to detect vertical and horizontal distribution patterns of contaminant from suspected sources. The factory oil installations and pipelines were inspected along with factory engineers to trace possible leaks. At the site inspection a leak in the diesel pipeline was confirmed.

ii. Physical and chemical analysis of water
Water samples were collected from contaminated wells for the analysis of pH, Electrical Conductivity, Lead (Pb), Oil and Grease levels.
Sample collection was done according to Specification for potable water, Part 1-SLS 614: 1983. Preservation, transportation and analysis were done according to Standard

Methods for the Examination of water and wastewater APHA, 20th edition.

iii. Physical and chemical analysis of soil
The preliminary investigations revealed contamination of wells and suspected that the contaminants has travelled over the surface of shallow groundwater table; the water table was 2-3m deep. To detect the contamination levels soil samples were collected.

Method given for sampling and analysis of hydrocarbon contaminated soil in Technical Assistance Bulletins (TABs) prepared by Environmental Canada was followed in soil sampling. Accordingly, surface soil samples were collected near the diesel leak to a depth of 8-10cm using a clean stainless steel scoop. To detect shallow soil contamination, soil samples were collected from borrowing test pits- (TP) at most suspected routes at specified depths up to of water table. Test pits were borrowed using an excavation machine. The test pits locations and observations made on excavated material are presented in Table 1.

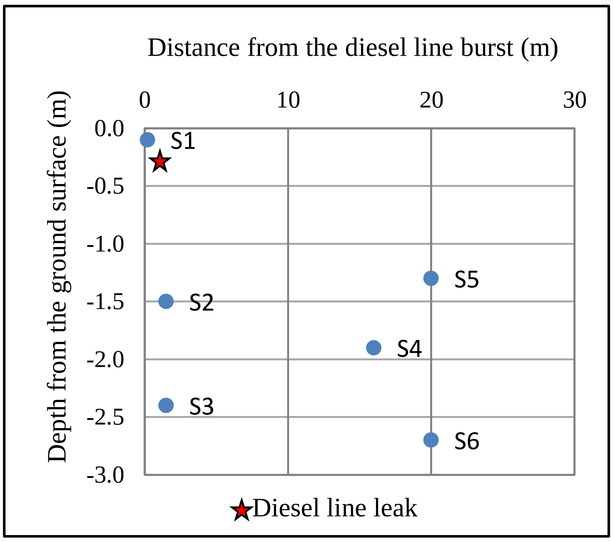
Table 1 Location of test pits and observations during excavation

Test Pit No.	Location and observations
TP1	About 1.5m from the diesel line burst towards the sloping direction of the land. When excavating, floating oil was noted on the water table
TP2	About 16m from the diesel line burst opposite to the sloping direction and parallel to the underground diesel storage tank. When excavating floating oil was noted on the water table.
TP3	About 20m from the diesel line burst towards the sloping direction and is 1-2 from the highly contaminated well. When excavating floating oil was noted on the water table

From these test pits soil samples (6) were taken at different depths from surface to ground and water table to detect oil and grease levels. (Fig.1- Layout diagram of soil sampling locations). Soil samples were taken in polythene bags which were previously rinsed with n-Hexane to analyse Oil and grease content using EPA-1664A.

- S1- from the surface near the diesel line burst
- S2 & S3- from Test Pit 1 (TP1)
- S4 & S5- from Test Pit (TP2)
- S6 from Test Pit 3 (TP3)

Fig. 1 Layout map of soil sampling locations



iv. Identification of source of contamination (diesel or kerosene).
Identification of oil as diesel or kerosene was done according to the density test - ASTM-D1217 and ASTM D 1298. Oil extracted from contaminated wells, the oil transporting in the line (raw diesel sample) and kerosene were tested for density.

Fig. 2Showing excavated test pits

2 RESULTS

The suspected oil contaminated land is an approximately ¼ acre in size located adjoining a rubber manufacturing factory bordered by a brick made boundary wall. One large well is located at the middle of the land and neighboring homesteads around the land have wells. The well water has been used for drinking, washing and bathing.

The communities who used the wells had been experiencing mineral oil smell and bad taste in their drinking water obtained from wells for about two months period. The community complain that the factory management had been disregarding the complaints under the impression that community had added Kerosene oil in to their wells purposely with the intention of getting compensation.

When NBRO has been requested to investigate the matter, at the site screening a leak in the diesel pipeline running parallel to the boundary wall of the factory was observed. The dark coloration in soils and smelling of mineral oil around the point of discharge inferred that the leak had been there for a long time. Also, it was noted that to phography of the land is towards the contaminated wells. Floating oily like sheen was observed in wells and the levels decreased towards the wells located at the direction of sloping land.

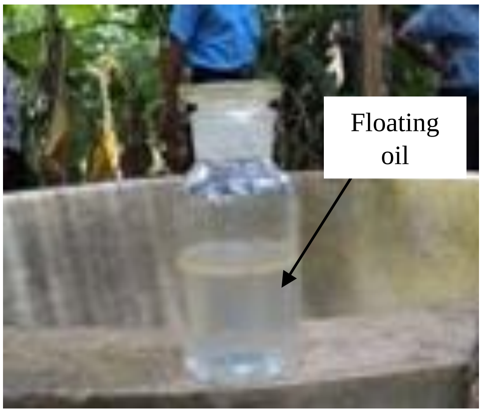


Fig.3 Sample of well water appearing floating oil

The pH, Electrical Conductivity (EC) and Oil and Grease levels in wells are presented in Table 2. The results show all wells were acidic in pH. The Electrical Conductivity levels in wells were 110-245 µS/cm. The lead (Pb) levels in all wells were<0.04mg/L. The level is below the maximum permissible level; 0.05 mg/L for potable water SLS 1983.The oil and grease value vary from 2.3 -11.1 mg/L. The highest value was observed in the well located about 18m away from the point of burst towards sloping direction of the land and lowest is observed in the well; W4 located about 60m away from the burst -opposite to the sloping direction. All levels exceeded the maximum Permissible level (0.1mg/L) for potable water given in the Sri Lanka Standards.

Table 2 Physical and chemical properties of well water

Location of wells	pH	EC, µS/cm	Oil and grease level, mg/L
W1-18m away from the burst –towards the sloping direction of the land	5.3	161	11.1
W2-50m away from the burst –towards the sloping direction of the land	5.2	245	3.5
W3-80m away from the burst –opposite to the sloping direction of the land	4.8	110	3.6
W4- 60m away from the burst –opposite to the sloping direction	5.2	155	2.3

Oil floating on the groundwater was observed in test pits. Observation on odour and the results of oil and grease levels of the soil collected from the contaminated site is presented in table 3.

Accordingly, the highest levels were observed near the soil collected from the burst pipeline. Next highest is observed from the soil sample collected from the test pit dug near highly contaminated well. Through the oil levels it was justified that contaminant has reached the ground water table. Contaminant levels were higher in deeper soils than the shallow layers towards the sloping direction away from the spill. This suggests that the contaminant movement in the soil has migrated both horizontal and vertical directions. The findings further inferred that oil has been releasing and contaminating the groundwater for a long period and contaminated oil has been migrated at the soil-water interphase in deeper soil layers along the sloping direction. (Fig.4 Layout map showing location of well, test pits and contaminant migration pathway)

Table 3 Observations on order and oil and grease levels in soil samples

Soil sample reference	Odour	Oil and grease level, mg/kg
S1	Mineral oil smell	19600
S2	No smell of mineral oil	100
S3	Slight mineral oil smell	3200
S4	No smell of mineral oil	100
S5	No smell of mineral oil	100
S6	Mineral oil smell	16400

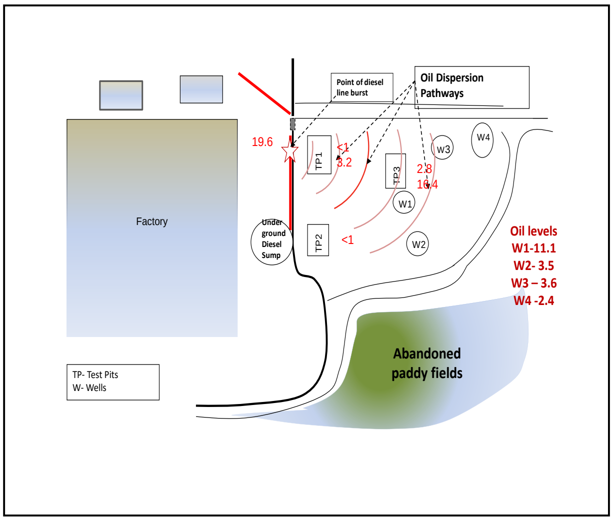


Fig.4Layout map showing location of well, test pits and contaminant migration pathway

The results of oil density of samples from wells (Table 4) were more or less similar to the sample of diesel obtained from the factory which is used as the fuel oil and it was confirmed that it is not kerosene (if kerosene the density should be below 820.0, kgm^{-3}).

Table 4 Results of density test

Sample	Test	Method	Result
Extracted oil from water samples collected from the site	Density @15 0C, kg m^{-3}	ASTM – D1217	825.5
Raw diesel sample	Density @15 0C, kg m^{-3}	ASTM – D1217	832.3

Soon upon conformation of contamination, the company initiated a full strength remediation by pumping out the groundwater and separation of oils, excavation of contaminated soil and treatment with dispersant. The families affected were given with clean drinking water and compensation for the damage caused.

3 DISCUSSION

The study confirmed that the leaking diesel oil has been spreading over several dimensions in the vadose and phreatic zones finally contaminating the neighboring domestic water wells. The leak has been left unnoticed over longer period by the company has resulted release of substantial quantity of oil into the environment which could have prevented if the leak was observed early. In Sri Lanka the enforcement of environmental regulations in operating factories depend largely on issuance of Environment Protection License based on pollution emission test reports. But factories potential to release large quantities of chemicals in accidents such as explosions, fires, floods, earth quakes etc or in situations of sudden leaks and spills are very high which certainly is a subject on disaster management. At present, management of chemical disaster has not been given due attention in national disaster management. Chemical disasters if happen cause tremendous damage to a larger population and to the environment several time more than a natural disaster would do. Therefore, preparedness on prevention and handling disaster situations, and post disaster management of chemical hazards require to be given serious attention in the mandate of disaster management in the country which should essentially include necessary institutional strengthening including of manpower, technology etc.

REFERENCES

Approval of EPA Methods 1664, Revision A, and 9071B for Determination of Oil and Grease and Non-polar Material in EPA's Wastewater and Hazardous Waste Programs

Sampling and analysis of hydrocarbon contaminated soil – Environment Canada

Specification for potable water, Part 1-SLS 614: 1983.

Standard Methods for the Examination of water and wastewater APHA, 20th edition.