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Research Article

Assessment of physiochemical, heavy metal and indicator bacterial groups in water and soil samples of different oil contaminated regions, Tiruchirappalli city

C. Vinothini* and R. Ravikumar

Post Graduate and Research Department of Botany, Jamal Mohammed College, Affiliated to Bharathidasan University, Tiruchirappalli, Tamil Nadu - 620 020, India.

***Correspondence Info:**
C. Vinothini
Post Graduate and Research Department of Botany,
Jamal Mohammed College, Affiliated to Bharathidasan University,
Tiruchirappalli, Tamil Nadu - 620 020, India.
E-mail: vinothinianand@yahoo.com

Abstract

The levels of physiochemical, heavy metal and microbiological pollution in different oil contaminated regions of Tiruchirappalli city were reported in the study. The water and sediment samples from four different oil contaminated regions in Tiruchirappalli city were collected during monsoon 2015. The sampling regions were divided into two category such as heavy oil contaminated regions (oil shed / oil washed regions) and bus stand regions. In oil contaminated water sample, the ranges of pH, TDS, EC, DO, BOD, COD, TA, TH, Ca, Mg, Na, K, HCO_3, CO_3, Cl, SO_4, N-NO_2, O-PO_4 and oil-grease were 7.4-8.4, 395.4-651.4 mg/L, 670.2-1104.1 µS/cm, 0-1, 3.4-6.4, 5.5-76.9, 14.2-17.4, 74.5-165.4, 24.4-159.9, 16.0-81.5, 8.4-78.4, 24.5-66.3, 21.5-48.9, 86.7-161.4, 0 - 0, 79.5-145.2, 48.5-115.6, 2.3-15.2, 6.2-14.4 and 7.9-15.4 mg/L, respectively. But in soil sample, the ranges of Cd, Cr, Cu, Fe, Ne Pb and Zn were 0.14-0.65, 0.11-0.22, 0.19-0.52, 0.91-3.46, 0.1-0.2, 0.12-0.22, 0.65-1.82 mg/kg, respectively. In oil contaminated water sample, counts of TVC, TC, TS, FC, FS, VC, SAC, SHC and PC were in the range of 21300-126000, 1620-13200, 240-1050, 250-1130, 100-250, 120-180, 80-160, 130-200 and 260-560 CFU/mL, respectively. In soil sample, the TVC, TC, TS, FC, FS, VLO, SC and PC ranges were 56000-218000, 3100-14800, 350-1260, 330-1420, 150-300, 110-240, 120-200, 160-260 and 410-1060 CFU/g, respectively. The results of this study indicated that oil shed regions got higher pollutions than bus stand regions. This study gave a special emphasis on the determination of the levels of pollution and also identified the vulnerable regions. Hence, throughout impoundment and continuous monitoring is needed.

Keywords: Oil contamination, Bacterial pollution, Physiochemical parameters, Heavy metals, Tiruchirappalli city.

1. Introduction

Pollution of the environment by any oil products is an inevitable consequence of oil production, transportation and distribution activities. Large amounts of oil products handled on land every year create the possibility for land contamination. In addition, large volumes of crude oil and/or refined petroleum products are transported across the world's oceans from producing areas to consumer countries[1][2]. The pollutants mainly constitute heavy metals, petroleum hydrocarbons and bacterial contaminants[3]. Oil contamination destroys soil fertility, causes alterations in soil physicochemical and microbiological properties, thereby having detrimental effects on the terrestrial and aquatic ecosystems. Oil spills also cause epidemics of many diseases because spilled oils contain toxic substances [4], which could be injurious to human health. The discharge of used oil from vehicles or motorcycles is a major source of oil pollution in mechanic workshop and its environs. The indirect effects of oil spills in soil include oxygen deprivation of plant roots as a result of exhaustion of the soil oxygen by oil-degrading microorganisms, which create anaerobic conditions that may lead to the formation of hydrogen sulphide [4][5]. The direct effect on the ecosystem includes damage of fur and feathers of birds, making them prone to death by freezing.

As a result of these effects on the ecosystem, the release of oil into the environment has caused serious environmental concern and attracts public attention [4][6]. In order to reduce or eliminate the effect of oil spillage on the environment and living organisms, physical, chemical and biological methods have been employed. The toxicity of crude oil or petroleum products varies widely, depending on their composition, concentration, environmental factors and on the biological state of the organisms at the time of

the contamination. Urban waste often represents the main source of microbial contamination of water and soil, which often determines a great limitation for human health in recreational activities and the direct/ indirect utilization of economic resources. Efforts such as application of chemical dispersants, skimming of the surface oils, application of biological oil agents and inoculating the spilled areas with relevant microbes are the outcomes of intensive research.

The most promising of many researches carried out to deal with large-scale oil spills is the use of microorganisms to provide an effective alternative [4][7]. This approach is referred to as bioremediation. Okon and Hernandez [8] in 2006; explained that bioremediation as an important process that uses microorganisms or their enzymes to remediate the environment altered by contaminants. Biodegradation of hydrocarbons by natural population of microorganisms represents one of the primary mechanisms of eliminating petroleum pollution from the environment [2][9]. The ability to degrade and/or utilize hydrocarbon substrates is exhibited by a wide range of bacteria and fungi [1][2]. In this study, the physiochemical, heavy metals and microbiological parameters has been analyzed during the monsoon season in different oil contaminated regions of Tiruchirappalli city.

2. Materials and methods

2.1 Study area

The Tiruchirappalli city is one of the largest municipality and big urban agglomeration in the Tamil Nadu state. Tiruchirappalli being sited almost at the centre of the state. Many industrial and densely residential areas have recently been developed in all part of the city and around 1.5 million people are living in this city. According to the 2011 Indian census, Tiruchirappalli had a population of 847, 387, 9.4% of whom were under the age of six, living in 214, 529 families within the municipal corporation limits.

2.2 Sampling

The four different oil contaminated regions in Tiruchirappalli city were selected for sample collection. The oil contaminated water and sediment samples were collected during monsoon 2015 for physiochemical, trace metal and bacteriological analysis. The sampling regions were divided into two category such as heavy oil contaminated regions (oil shed / oil washed regions) and bus stand regions. The sampling sites were Ponmalai Railway Shed, Senthaneerpuram Oil Shed, Chatram Bus Stand and Central Bus Stand, and were marked as PRS, SOS, CHB and CLB, respectively. The water and soil samples were marked as W and S, respectively. The oil contaminated water samples were collected from 0 to 10 cm below the surface. The 2000 mL of water samples were collected with a 2500 mL sterile container in each locations. The sediment samples were collected by sterile spatula and stored in sterile plastic bags [10][11].

2.3 Physiochemical analysis

The physiochemical parameters, i.e., pH, electrical conductivity (EC), total dissolved solids (TDS) and salinity were measured using field kit (Thermo Orion 5-Star pH Multi-Meter) on the site and the concentrations of soluble cations, anions and nutrients (around 15 parameters) were determined according to the standard methods [12-14]. All samples were collected with precautions required for all analysis, held on iceboxes and processed within 6 h of collection.

2.4 Trace metal analysis

The one liter of oil contaminated water was acidified immediately with concentrated nitric acid (HNO_3) after collection of the sample and was filtered by Whatman No.1 filter paper. After filtration, the sample was processed (APDC + MIBK) for metal analysis. The sediment samples were air-dried and smaller than (>) 63 µm in size were retained in pre-cleaned properly. Thereafter, the dried sediment samples were crushed by agate mortar and pestle. The crushed soil sample was treated with aqua-regia mixture (i.e. $HCl:HNO_3$= 3:1) in Teflon bomb and were incubated at 140 °C for 2-3 days after dried and sieved samples. After incubation, the reaction mixture was filtered with Whatman No.1 filter paper. The trace metals in the water and soil sample were determined by the atomic absorption spectrophotometry (GBC SensAA - AAS, Australia) in flame mode [15].

2.5 Bacteriological analysis

The bacterial populations in different samples were estimated by pure culture technique (spread plating method) on selective medium plates with 100 µL of suitable dilutions [16]. In this study, the selective media were prepared with the addition of double distilled water and autoclaved properly. After addition of sample on selective media plates, the plates were incubated at 37°C ± 1°C for 24–48 h, except M-FC agar plates. The M-FC agar plates were incubated at 44.5°C ± 1°C for 24–48 h [11]. After incubation, the final counts of colonies were noted and all trials were performed in triplicate. For confirmation of the pathogens, typical colonies were inoculated into Rapid Microbial Limit Test kits recommended for diagnostic microbiology supplied by Hi-media Laboratories Limited[13][14]. Each bacterial group, color, incubation time and specific media was listed in Table 1.

Table 1: Details of specific culture media used for quantitative bacterial analysis

S. No	Bacterial Indicators	Culture medium	Positive Colonies	References
1.	Total Viable Count (TVC)[a]	Nutrient Agar	All colonies counted	Vignesh *et al*[13]
2.	Total Coliforms (TC)[a]	MacConkey Agar	All colonies counted	Vignesh *et al*[13]
3.	Total *Streptococci* (TS)[a]	M *Enterococcus* Agar	All colonies counted	Kumarasamy *et al*[16]
4.	Fecal Coliforms (FC)[b]	M FC Agar	Blue colonies counted	Vignesh *et al*[13]
5.	Fecal *Streptococci* (FS)[a]	KF *Streptococcus* Agar	Red colonies counted	Vignesh *et al*[14]
6.	*Vibrio* count (VC) [a]	TCBS Agar	Yellow colonies counted	Vignesh *et al*[13]
7.	*Salmonella* count (SAC) [a]	XLD Agar	Black colonies counted	Kumarasamy *et al*[16]
8.	*Shigella* count (SHC) [a]	XLD Agar	Red colonies counted	Kumarasamy *et al*[16]
9.	*Pseudomonas* count (PC) [a]	Cetrimide Agar	All colonies counted	Vignesh *et al*[10]

[a] Media plates were incubated at 37°C ± 1°C for 24–48 h; [b] Media plates were incubated 44.5°C ± 1°C for 24–48 h

3. Result and Discussion

Crude oil samples obtained from different oil fields vary both in physical and chemical properties. This is due to different proportions of the various molecular types, sizes of hydrocarbons and other elemental constituents in the crude mix. Petroleum fluids are complex fluids, normally of undefined composition that require a characterization procedure to obtain relevant information. The ever-increasing chemical utilization of crude oils and petroleum products were better knowledge of the composition, structure and properties of their fractions. Parameters often determined in crude oil include: Density, API gravity, Pour point, Kinematic Viscosity, Water content (%) Salt content (%) Sulphur content (%), Asphaltene (%), ASTM Distillation cracking point as well as Metal/mineral contents [17-20].

Physicochemical properties of the ambient marine environment will play a vital role in determining the type of ecosystem. In oil contaminated water sample, the ranges of pH, TDS, EC, DO, BOD, COD, TA, TH, Ca, Mg, Na, K, HCO_3, CO_3, Cl, SO_4, N-NO_2, O-PO_4 and oil-grease were 7.4-8.4, 395.4-651.4 mg/L, 670.2-1104.1 µS/cm, 0-1, 3.4-6.4, 5.5-76.9, 14.2-17.4, 74.5-165.4, 24.4-159.9, 16.0-81.5, 8.4-78.4, 24.5-66.3, 21.5-48.9, 86.7-161.4, 0 - 0, 79.5-145.2, 48.5-115.6, 2.3-15.2, 6.2-14.4 and 7.9-15.4 mg/L, respectively (Figure 1-4).

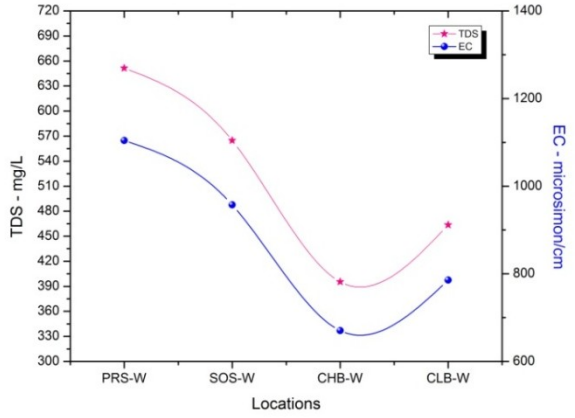

Figure 1: EC and TDS level in water sample

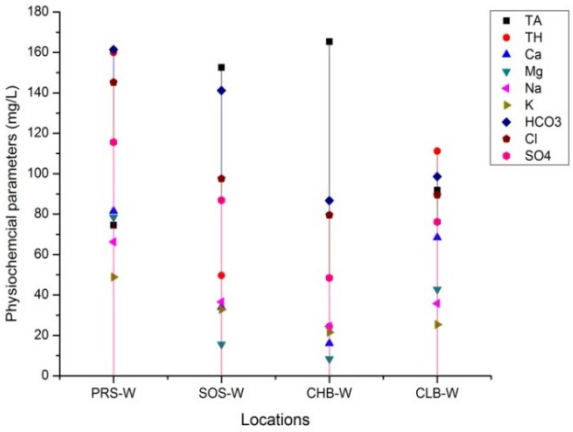

Figure 2: TA, TH, Ca, Mg, Na, K, HCO_3, Cl and SO_4 level in water sample

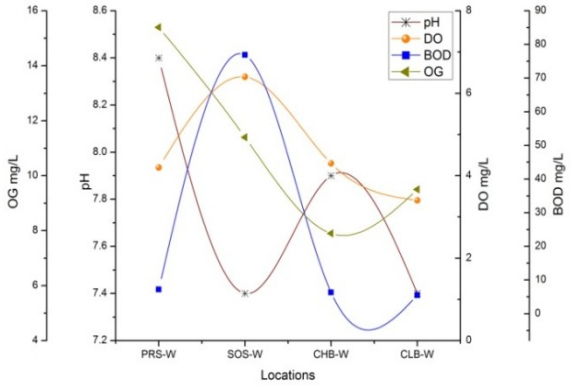

Figure 3: pH, DO, BOD and Oil-Greece level in water sample

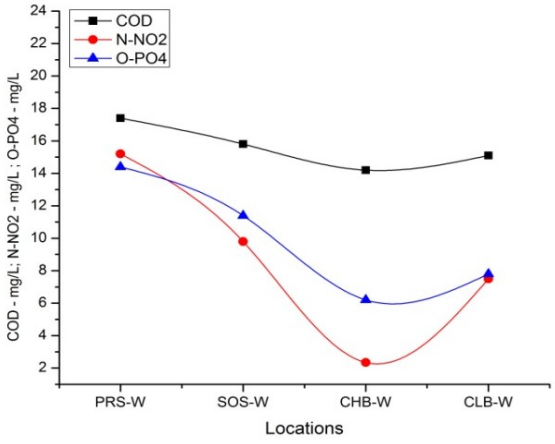

Figure 4: COD, N-NO_2 and O-PO_4 level in water sample

But the range of pH, TDS, EC, DO, BOD, COD, TA, TH, Ca, Mg, Na, K, HCO_3, CO_3, Cl, SO_4, N-NO_2, O-PO_4 and oil-grease in oil contaminated soil sample were 7.8-8.5, 655.2-1956.8 mg/L, 110.5-3316.6 µS/cm, 1-3, 4.1-6.1, 6.1-13.5, 12.6-18.4, 140.8-246.8, 16.1-142.5, 8.2-82.3, 32.8-140.5, 21.6-63.2, 112.4-224.6, 0-0, 97.5-465.8, 56.4-137.2, 3.4-13.6, 5.0-10.1 and 15.2-21.6 mg/kg, respectively (Figure 5-7).

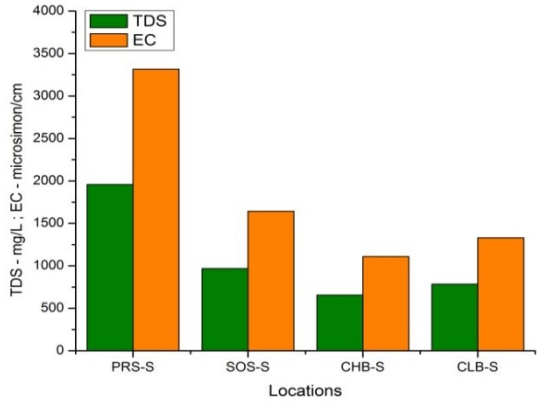

Figure 5: TDS and EC level in soil sample

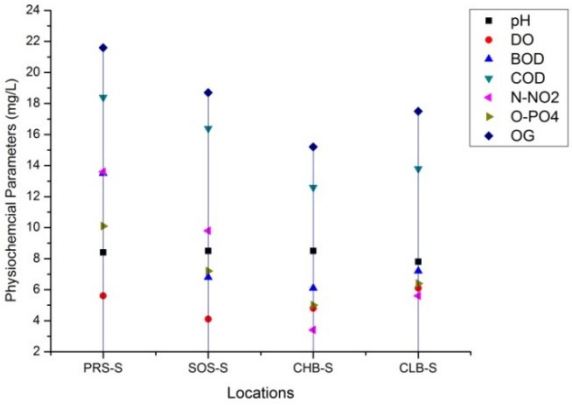

Figure 6: pH, DO, BOD, COD, N-NO_2, O-PO_4 and oil-Greece level in soil sample

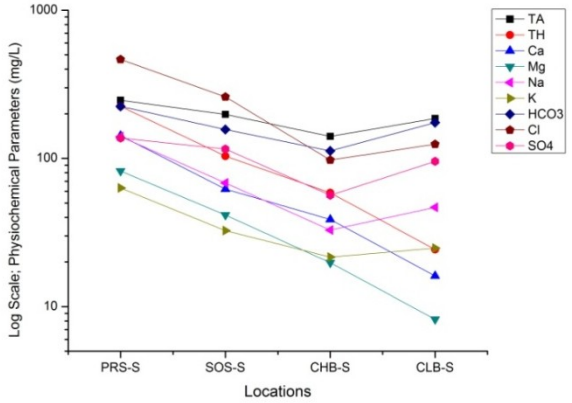

Figure 7: TA, TH, Ca, Mg, Na, K, HCO_3, Cl and SO_4 level in soil sample

The physiochemical parameters were high and 2-3 fold higher in Gokana oil polluted site [21] than our sampling sites. Interestingly, the heavy metal concentrations were high in our study than the Gokana oil polluted site. Heavy metals in environment mostly come from lithogenic and anthropogenic sources. Discharge of urban and industrial waste water, combustion of fossil fuels, mining and smelting operations, processing and manufacturing industries, waste disposal including dumping, etc., are primary anthropogenic sources of pollution [22]. In our study, the ranges of heavy metals such as Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations in oil contaminated water sample were 0.13-0.34, 0.1-0.15, 0.12-0.32, 0.55-1.84, 0-0.1, 0.11-0.14 and 0.48-1.24 mg/L, respectively. But in soil sample, the ranges of Cd, Cr, Cu, Fe, Ne Pb and Zn were 0.14-0.65, 0.11-0.22, 0.19-0.52, 0.91-3.46, 0.1-0.2, 0.12-0.22, 0.65-1.82 mg/kg, respectively (Figure 8-9).

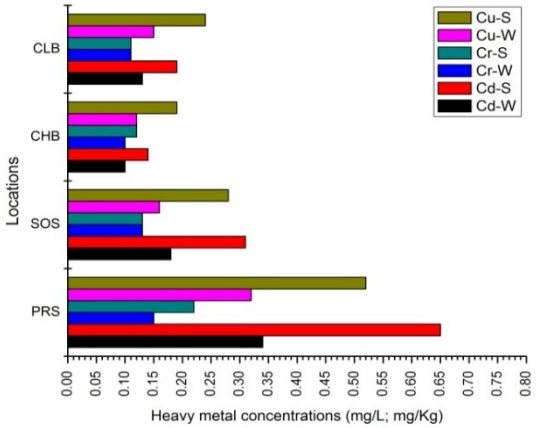

Figure 8: CD, Cr and Cu level in water and soil sample

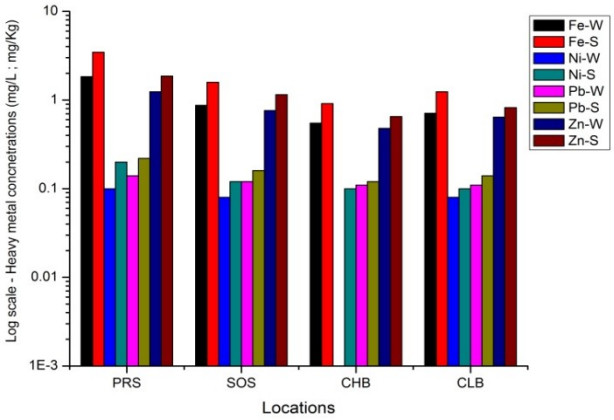

Figure 9: Fe, Ni, Pb and Zn level in water and soil sample

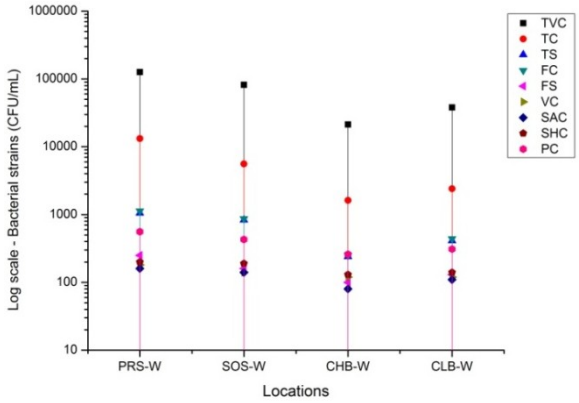

Figure 10: Microbiological parameter levels in water sample

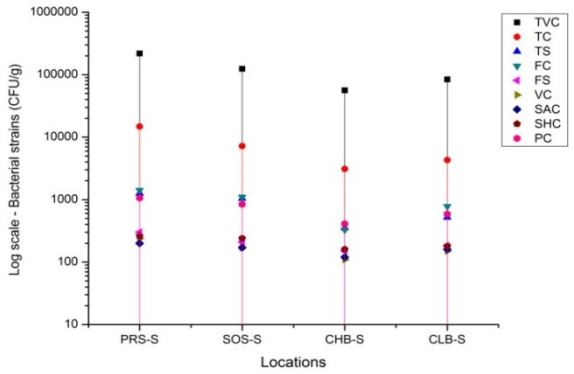

Figure 11: Microbiological parameter levels in soil sample

Environmental surveys are necessary for understanding and documenting the occurrence and distribution of pollution indicator and human pathogenic bacteria. In order to quantify and understand their relationship with relevant environmental factors, several investigators have examined distribution of these groups of bacteria and certain viruses in different water and soil samples. In oil contaminated water sample, counts of TVC, TC, TS, FC, FS, VC, SAC, SHC and PC were in the range of 21300-126000, 1620-13200, 240-1050, 250-1130, 100-250, 120-180, 80-160, 130-200 and 260-560 CFU/mL, respectively (Figure 10). In soil sample, the TVC, TC, TS, FC, FS, VLO, SC and PC ranges were 56000-218000, 3100-14800, 350-1260, 330-1420, 150-300, 110-240, 120-200, 160-260 and 410-1060 CFU/g, respectively (Figure 11). Urban canals receiving domestic sewages and several pollutants like oil pollutants from petrol bunks, mechanic shops, cement/ paint waste etc may contribute to the establishment of dissemination routes by microorganism carrying antimicrobial resistance genes [23][24]. In this study, the indicator bacterial levels were crossed the permissible/ standard limits [25][26]. The sediments generally contain higher concentrations of bacteria than the water column [14].

4. Conclusion

In this study, the physiochemical, trace metal and microbiological analysis indicated that these sites were highly contaminated by the diverse pollutants and were also contains high oil contents which influence the microbial growth, behavior and their potential. The microbial study of the samples were crossing the permissible limits of the BIS [25] and WHO [26]. All the parameters concentrations were high in soil than the water samples. This study emphasized that when oil spill occurs, it poses a long term threat to all forms of life. Hence, immediate remediation technology should be carried out to safe the environment. Due diligence to be adhered to for continuous monitoring to validate the effectiveness of mitigation.

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