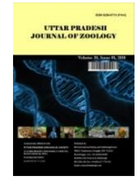
UTTAR PRADESH JOURNAL OF ZOOLOGY

41(23): 62-71, 2020
ISSN: 0256-971X (P)



ASSESSMENT OF SOIL AND WATER QUALITY AND ITS POSSIBLE IMPACT ON THE FLORA AND FAUNA IN JAYARAMPETTAI VILLAGE OF RANIPET DISTRICT, TAMIL NADU, INDIA

SUBRAMANIAN ARIVOLI[1], SAMUEL TENNYSON[2*], GANESAN MANIMEGALAI[1], ELANGOVAN VIGNESHKUMAR[1], MOHAMED MEERAN[3], GRACE MARIN[4], MIRIAM VASSOU[5], SELVARAJ DIVYA[1] AND PAC KAMATCHI[6]

[1]Department of Zoology, Thiruvalluvar University, Vellore 632 115, Tamil Nadu, India.
[2]Department of Zoology, Madras Christian College, Chennai 600 059, Tamil Nadu, India.
[3]Department of Zoology, Hajee Karutha Rowther Howdia College, Uthamapalayam 625 533, Tamil Nadu, India.
[4]Department of Zoology, Scott Christian College, Nagercoil 629 003, Tamil Nadu, India.
[5]Department of Zoology, Periyar EVR College, Tiruchirappalli 620 023, Tamil Nadu, India.
[6]Department of Zoology, Arignar Anna Govt. Arts College for Women, Walajapet 632 513, Tamil Nadu, India.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors designed the study and wrote the protocol. Authors SA and ST wrote the first draft of the manuscript. Authors SA, GM and EV managed the analyses of the study. All authors managed the literature searches. Author ST performed the statistical analysis and also edited the final draft of the manuscript. All authors read and approved the final manuscript.

Article Information

Editor(s):
(1) Dr. Ana Cláudia Correia Coelho, University of Trás-os-Montes and Alto Douro, Portugal.
Reviewers:
(1) Yalçın Tepe, Mustafa Kemal University, Turkey.
(2) Alhassan H. Ismail, Middle Technical University, Iraq.
(3) Dippong Thomas, Technical University of Cluj Napoca, Romania.

Received: 12 October 2020
Accepted: 18 December 2020
Published: 11 January 2021

Original Research Article

ABSTRACT

The quality of soil and water from Jayarampettai village of Ranipet district, Tamil Nadu, India were tested from January 2019 to December 2019, and checked for its impact on the flora and fauna. The physicochemical, macronutrient and metal parameters for soil tested in the study area reported higher concentrations of iron and manganese which act as important indicators for environmental risk assessment creating awareness towards safe guarding of flora and fauna biodiversity. However, the metal parameters during water analysis were nil. The soil quality in polluted condition due to industrialization will certainly cause harm to the growth and quality of plant and animal life. Future studies on soil and water analysis of other villages in Ranipet district would determine the quality of soil and water for biotic community.

**Corresponding author: Email: samtennyson@gmail.com;*

Keywords: Soil; water; parameters; Jayarampettai; Ranipet.

1. INTRODUCTION

Ecologically, Ranipet is the one of the most strategic place where numerous industries started mushrooming, and is strongly influenced by soil and water contamination of industrial origin. The Ranipet industrial zone has been particularly polluted for a long time in light of unrestrained disposal of hazardous wastes from industrial facilities and exhaust gasses. As a result of the index of geoaccumulation, enrichment factor, contamination degree, and integrated pollution index applications, very high concentrations of pollutants were found in the soils and waters of Ranipet industrial area. The water nature of this region is constantly debasing due to industrial, domestic and agricultural activities. High concentrations of metals in the Ranipet soils too may be blended with groundwater by leaching [1]. The element concentrations can be introduced into the food chain via soil and water, and may be a serious threat for plant, animal and human health. Analysts have provided details regarding the soil and water quality of polluted sites of Ranipet [1-9]. Nevertheless, the investigation on the soil and water quality of Jayarampettai village of Ranipet district and its conceivable effect on flora and fauna has not been accounted for till date. Such assessment will highlight the quality of soil and water for regular and other anthropogenic impacts, and along these lines, the same was assessed in the present study.

2. MATERIALS AND METHODS

2.1 Study Area and Study Design

Jayarampettai village (12°55' 55.4268" N and 79°20' 0.4776" E) is located 20Km away from Ranipet district, Tamil Nadu, India (Fig. 1). It is encircled by tannery and industrial units which includes leather and tanning industries, shoe factories, water effluent industries, ceramic industries, chemical factories, and dyeing electroplating industries. The study was done from January 2019 to December 2019. Sampling of soil and water was done in the early hours of morning, and transferred to the laboratory, with a minimum of three samples each. All the chemicals and reagents utilized in the present study were of analytical grade, purchased from Merck, India. Analytical grade water from Millipore water purification system (Make: Millipore, USA; Model: Elix and Synergy) was utilized for the preparation of all standards and solutions. The procedure adopted for analysis of soil and water parameters are tabulated and presented in Table 1.

2.2 Soil Analysis

Stratified random sampling was undertaken. The study area was partitioned into three zones *viz*., industrial area (zone 1), 10 km from industrial area (zone 2), and agricultural land/fields (zone 3). Soil parameters like soil texture, pH, electrical conductivity, macronutrients (nitrogen, phosphorous, potassium), and metals (iron, manganese, zinc, and copper) were analysed. Sampling procedures for soil samples were strictly followed wherein, first a uniform slice of the soil was taken from the surface to the depth of the insertion, and secondly, the same volume of soil was obtained in each sample. All soil sampling equipment's were decontaminated prior to sample collection. Soil samples taken at a depth greater than three inches was collected with the aid of a hand auger. Care was taken that the soil sample was neither touched nor handled by bare hands. The collected samples were cleared off for stones, plant residues and other undesirable materials if any, and then packed in plastic bags.

2.3 Water Analysis

Three distinctive water sources, *viz*., effluent, corporation and bore well samples were examined for their physicochemical (appearance, colour, odour, turbidity, total dissolved solids, electrical conductivity, pH, alkalinity, total hardness), nutrient (calcium, magnesium, sodium, potassium, free ammonia, nitrite, nitrate, chloride, fluoride, sulphate, phosphate), and metal (iron and manganese) properties. Water samples (1000 mL) were collected in high-density polyethylene Tarson brand bottles after 2-3 times rinsing with the sample.

2.4 Statistical Analysis

Correlation matrix analysis was performed using SPSS software [10] for soil and water independently to determine significantly the parameters responsible for influencing the soil and water quality of the study area. The correlations among the parameters were assessed by the determination of Pearson correlation coefficients, with significance accepted at P=0.01.

3. RESULTS

The texture of soil was sandy loam in all the three zones analysed, and the results of soil parameters, *viz*., pH, electrical conductivity, macronutrients like nitrogen, phosphorous, potassium, and metals like iron, manganese, zinc and copper tested in zone 1, 2 and 3 reported values of 7.8, 8.0 and 8.4; 0.5, 0.2 and 0.9; 146, 150 and 128; 8, 49 and 5; 113.5, 88.5 and 100; 4.3, 3.9 and 3.9; 2.3, 2.5 and 2.1; 0.5, 0.2 and 0.5; and 0.8, 0.9 and 0.7 respectively (Fig. 2). Table 2 displays the correlation coefficients between the soil parameters in the study area. The results of the physicochemical, nutrient, and metal parameters of effluent, corporation and bore well water in the study area showed marked differences amongst them. The effluent water was slightly turbid, and pale yellowish in colour with a strong odour, whereas the corporation and bore well water were clear and colourless, without odour. The physicochemical parameters, *viz*., water temperature, electrical conductivity, turbidity, total dissolved solids, pH, total alkalinity and total hardness for effluent, corporation and bore well water were 28, 29 and 36; 3700, 692 and 1857; 6, 1 and 2; 2590, 484 and 1300; 7.2, 7.9 and 7.2; 488, 156 and 268; and 990, 192 and 468 respectively (Fig. 3). Calcium, magnesium, sodium, potassium, free ammonia, nitrate, nitrite, chloride, fluoride, sulphate and phosphate represented the nutrient parameters and their respective values were 204, 39 and 93; 115, 23 and 57; 0, 0 and 0; 0, 0 and 0; 0, 0 and 1.2; 30, 10 and 54; 0, 0 and 1.2; 810, 103 and 326; 0.4, 0.4 and 0.6; 356, 48 and 151; 0.3, 0 and 0. The respective values of metal parameters for iron and manganese was 0, 0 and 0.9; and 0, 0 and 0 (Fig. 4). Table 3 displays the correlation coefficients between the water parameters in the study area.

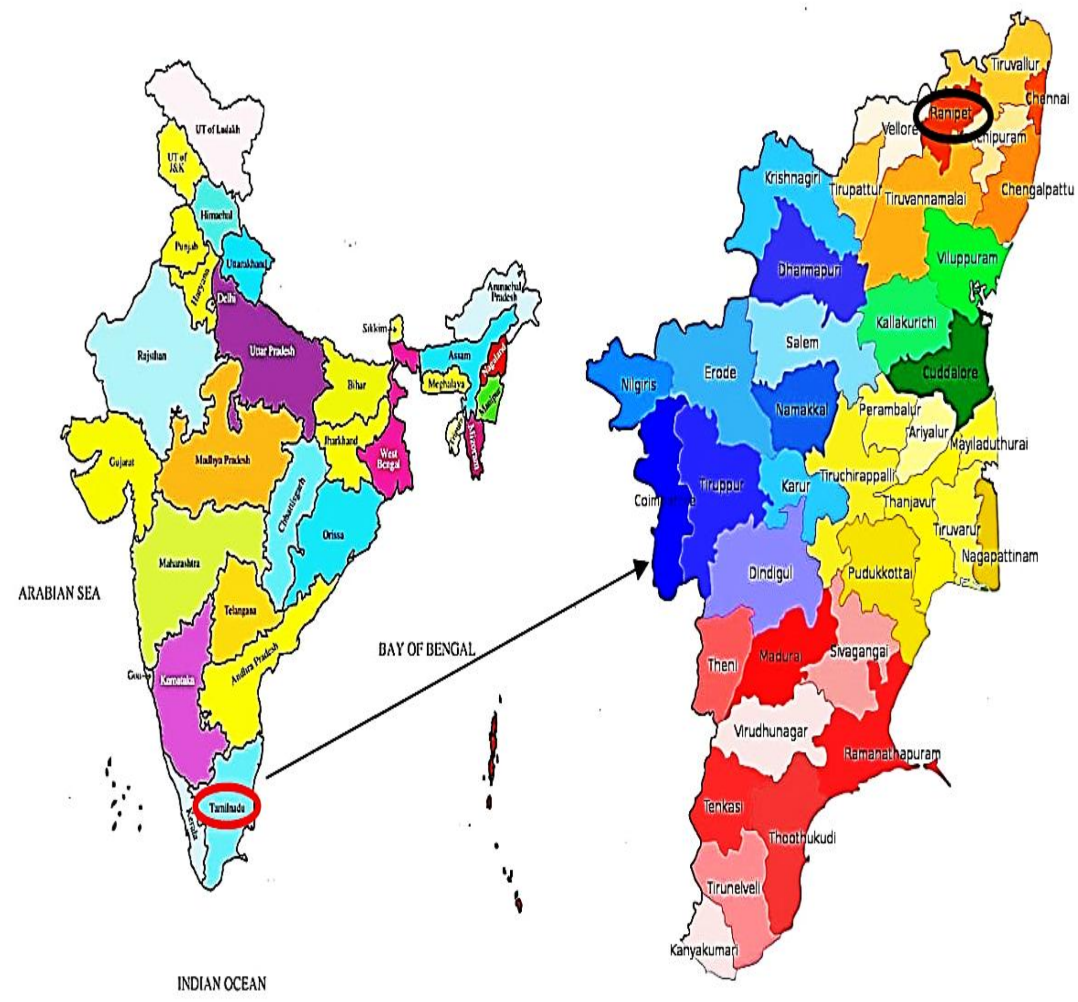


Fig. 1. Map of the study area

Table 1. Procedure for analysis of soil and water parameters

Parameters	Unit	Method
SOIL		
Physicochemical		
Texture	-	Hydrometer
pH	-	Systronic digital pH meter
Electrical conductivity	dS/m	Conductivity meter
Macronutrients		
Nitrogen	mg/Kg	Kelplus Distyl - EMS
Phosphorous		Colorimeter
Potassium		Flame photometer
Metals		
Iron	mg/Kg	Atomic absorption spectrophotometer
Manganese		
Zinc		
Copper		
WATER		
Physicochemical		
Colour/Appearance	Hazen	Visual comparison
Odour	-	Physiological sense
Temperature	°C	Mercury-in-glass thermometer
Electrical conductivity	µS/cm	Conductivity meter
Turbidity	NTU	Nephelometric turbidity meter
Total dissolved solids	mg/L	Ion selective
pH	-	Systronic digital pH meter
Total alkalinity	ppt	Acid titration
Total hardness		EDTA titration
Nutrients		
Calcium	mg/L	Flame photometer
Magnesium		Complexometric EDTA titration
Sodium		Flame photometer
Potassium		
Free ammonia		Complexometric EDTA titration
Nitrate		UV visible spectrophotometer
Nitrite		
Chloride		Argentometric titration
Fluoride		SPADNS spectrophotometer
Sulphate		Nephelometer and Turbidimeter
Phosphate		Stannous chloride
Metals		
Iron	mg/L	Atomic absorption spectrophotometer
Manganese		

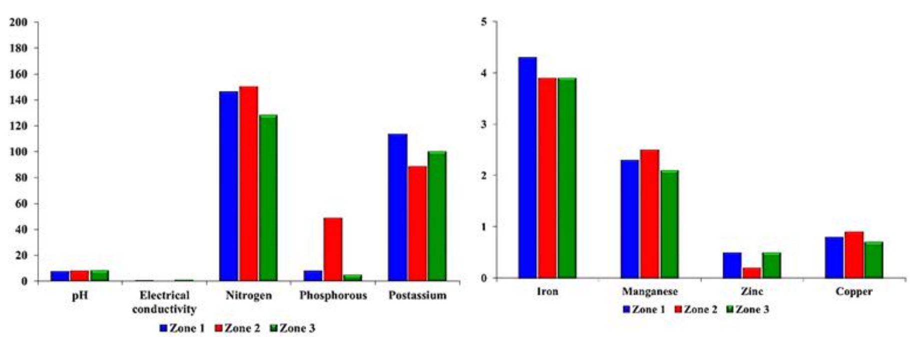


Fig. 2. Soil parameters in the study area

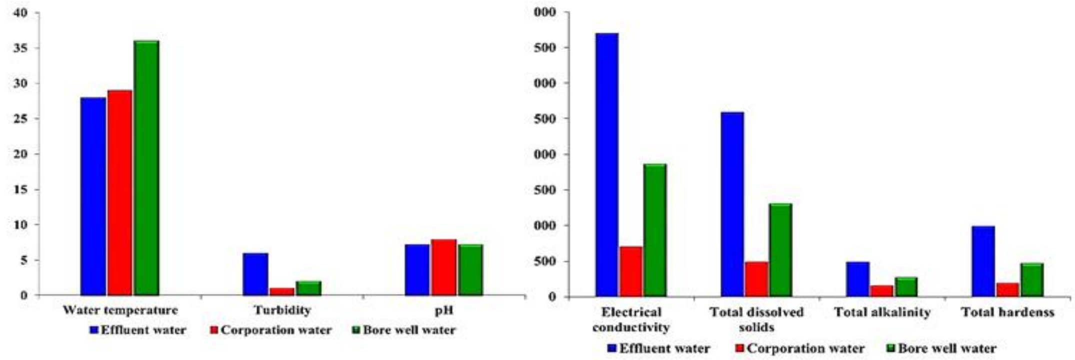


Fig. 3. Physicochemical parameters of water in the study area

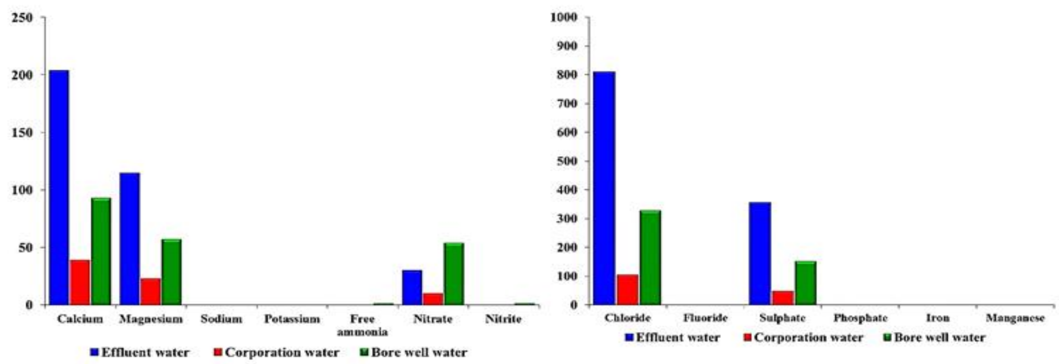


Fig. 4. Nutrient and metal parameters of water in the study area

Table 2. Correlation matrix of soil parameters in the study area

	pH	EC	NI	PH	PO	IR	MA	ZI	CO
pH	1								
EC	0.715	1							
NI	-0.875	-0.963	1						
PH	-0.248	-0.855	0.686	1					
PO	-0.370	0.384	-0.125	-0.807	1				
IR	-0.755	-0.082	0.344	-0.446	**0.888***	1			
MA	-0.654	-0.996	**0.938***	**0.894***	-0.459	-6.4E	1		
ZI	0.188	**0.821***	-0.640	-0.998	**0.842***	0.5	-0.866	1	
CO	-0.654	-0.996	**0.938***	**0.894***	-0.459	3E	1	-0.866	1

**Correlation significant @ P=.01. pH: Hydrogen ion concentration; EC: Electrical conductivity; NI: Nitrogen; PH: Phosphorous; PO: Potassium; IR: Iron; MA: Manganese; ZI: Zinc; CO: Copper*

4. DISCUSSION

The nature of soil and water depend upon various substance constituents and their obsession is generally evolved from the geological data of the particular village/area/district. By and large, the nature of soil and water relies upon the collaboration among soil and water, soil-gas connection, rocks with which it comes into contact in the unsaturated zone, and responses that occur inside [11,12]. Soil and water quality in an area is generally directed by disintegration and precipitation of minerals, water speed, nature of revive water, and relationship with different kinds of water, and anthropogenic exercises [13]. The regular substance nature of soil and water is commonly acceptable, yet raised centralizations of different constituents, can wreck soil and water use. Thus, soil and water information provides critical proof to its recharge, movement, development, capacity and storage [14].

Table 3. Correlation matrix of water parameters in the study area

	TE	EC	TU	TDS	pH	TA	TH	CA	MAG	SO	PO	FA	NTA	NTI	CH	FL	SU	PH	IR	MA
TE	1																			
EC	-0.241	1																		
TU	-0.433	**0.979***	1																	
TDS	-0.241	1	**0.979***	1																
pH	-0.397	-0.794	-0.654	-0.794	1															
TA	-0.296	**0.998***	**0.989***	**0.998***	-0.758	1														
TH	-0.287	**0.998***	**0.987***	**0.998***	-0.765	**0.999***	1													
CA	-0.306	**0.997***	**0.990***	**0.997***	-0.751	**0.999***	**0.999***	1												
MAG	-0.261	**0.999***	**0.983***	**0.999***	-0.781	**0.999***	**0.999***	**0.998***	1											
SO	NA	NA	NA	NA	NA	NA	NA	NA	NA	1										
PO	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1									
FA	**0.993***	-0.129	-0.327	-0.128	-0.5	-0.184	-0.175	-0.195	-0.148	NA	NA	1								
NTA	**0.833***	0.335	0.137	0.335	-0.838	0.281	0.290	0.270	0.316	NA	NA	**0.891***	1							
NTI	**0.993***	-0.129	-0.327	-0.128	-0.5	-0.184	-0.175	-0.195	-0.148	NA	NA	1	**0.891***	1						
CH	-0.319	**0.996***	**0.992***	**0.996***	-0.742	**0.999***	**0.999***	**0.999***	**0.998***	NA	NA	-0.208	0.258	-0.208	1					
FL	**0.993***	-0.129	-0.327	-0.128	-0.5	-0.184	-0.175	-0.195	-0.148	NA	NA	1	**0.891***	1	-0.208	1				
SU	-0.299	**0.998***	**0.989***	**0.998***	-0.756	**0.999***	**0.999***	**0.999***	**0.999***	NA	NA	-0.187	0.278	-0.187	**0.999***	-0.187	1			
PH	-0.596	**0.923***	**0.981***	**0.923***	-0.5	**0.943***	**0.940***	**0.947***	**0.930***	NA	NA	-0.5	-0.052	-0.5	**0.951***	-0.5	**0.944***	1		
IR	**0.993***	-0.129	-0.327	-0.128	-0.5	-0.184	-0.175	-0.195	-0.148	NA	NA	1	**0.891***	1	-0.208	1	-0.187	-0.5	1	
MA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1

NA: Not applicable. Correlation significant @ P=.01.

TE: Temperature; EC: Electrical conductivity; TU: Turbidity; TDS: Total dissolved solids; pH: Hydrogen ion concentration; TA: Total alkalinity; TH: Total hardness; CA: Calcium; MAG: Magnesium; SO: Sodium; PO: Potassium; FA: Free ammonia; NTA: Nitrate; NTI: Nitrite; CH: Chloride; FL: Fluoride; SU: Sulphate; PH: Phosphate; IR: Iron; MA: Manganese

Soil is a key part of the earth framework as it controls the hydrological, erosional, biological, and geochemical cycles [15]. Soils have been used to recognize the deposition, accumulation, and dissemination of heavy metals [16]. Physical and chemical assessment of soil relate the available soil nutrients with the soil properties [17]. Macronutrients have a significant role in the soil. Inadequacy of nitrogen influences the metabolic activity of the plants resulting in stunted growth, shorter internodes, light green and pale yellow leaves, and shedding of leaves and fruits [18,19]. Abundance of nitrogen is additionally an issue to the plant which will be revealed by the deferred development and susceptibility to insects and diseases. An insufficiency of phosphorous prompts impaired vegetative growth, weak root systems, purple stems and leaves, and poor yield of fruits and seeds [17,20]. Plants deficient in potassium are unable to utilize nitrogen and water efficiently, leading to chlorosis, defoliation, slow or stunted growth, weak unhealthy roots, uneven ripening of fruits, and poor resistance to temperature changes, drought, and pests [20]. Trace amount of metals assume an indispensable function in maintaining soil health and also productivity of crops, and are needed in very small amounts, and their deficiencies have become major constraints to productivity, stability and sustainability of soils [21]. Iron at low concentration causes yellowing of new leaves and green vein, and in excess causes tiny brown spots on lower side of leaves. Brown spots on the veins of the leaf blade and leaf sheath and stunted growth are indicative of its excess content of manganese [22]. Its deficiency leads to interveinal chlorosis which is a characteristic symptom, accompanied by infertility. Takkar et al. [23] stated that when the soils are low in organic matter they are prone to zinc deficiency which causes stunted growth and delayed maturity in plants, and on the other hand, excessive uptake of zinc by plants causes stunting, curling, rolling of young leaves, death of leaf tops and chlorosis. Copper inadequacy causes the tip of the leaves to turn to white, and its toxicity disturbs mitosis, inhibits root elongation, and damages root cell membrane [16]. Nonetheless, all the values of these metals in all the three zones were maintained, aside from iron and manganese which reported higher values in all three zones. The analytical results indicate that the trace metals were above the natural trace metal concentrations of soil samples which is a course of concern as these metals can accumulate to pollute the environment in turn threatening the biotic community.

Waters get contaminated owing to the discharges of wastewater containing degradable organics, nutrients, domestic effluent, and agricultural waste [24], and the water quality worsens due to anthropological pressure and climate changes [25]. Some trace organic contaminants and metals force impacts on human, animal life, and aquatic ecosystems [26]. The metal sources include rock erosion, sediment relocation, atmospheric dust particles deposition or waste water inputs [27]. One of the key physicochemical feature of any water is temperature as they are influenced by precipitation and accessibility of light. Temperature influences the chemical, biochemical and biological characteristics of the aquatic system and indirectly regulates the colouration in aquatic organisms, especially fishes. Water temperature affects the biotic and abiotic stream processes such as the amount of dissolved matter, organic and inorganic pollutants, nutrients, and as well as the behaviour of invertebrates and fishes [28]. High temperatures have a profound effect on the physicochemical properties, and the biotic spectrum present within the water. Low temperature achieves the darkening impact while its ascent results in the concentration of pigments with consequent lightning of the colour [29]. Naturally, water remains at low temperature and evaporates to high temperatures. High temperatures in natural waters are recorded when heated waters or effluents are discharged from industries or power plants which was observed in the present study. Turbidity additionally lessens the overall convenience and its high values limits the filter runs which cause pathogenic organisms to be more hazardous to human life and the values of the present study was within the permissible limits set by standards. pH is a basic biogeochemical parameter, which assumes a vital role in natural processes and is of general significance in an ecosystem. The pH of water is critical to survival of most aquatic plants and animals. pH is reflected as a noteworthy characteristic factor and conveys information on various kinds of geochemical balance [30], and is the major deciding component to water destructiveness [29]. Many aquatic species cannot survive if pH dips under five or transcends nine, as changes in pH alter the chemistry of water [31]. Alkalinity in itself is not harmful to human being, but in large quantity, imparts bitter taste to water and may cause eye irritation in human [32].

Dispersion of nutrients is due to seasonal, tidal conditions and freshwater flow from land sources. The presence of high amount of nutrients may be due to heavy influx of fresh water derived from land drainage, electroplating, tanning, dyeing and textile manufacturing industries. Calcium and magnesium determine the hardness of water and are considered as micronutrients that influence the growth of plant and animals. High sodium content indicates pollution from human and animal waste by open defecation in the vicinity of a water body. Potassium, an important macronutrient, generally appears in water and imparts softness and makes water salty. Though, found in small amounts, it plays a vital role in fish metabolism [33]. However, sodium and potassium were reported nil in the present study. Free ammonia is a product of decomposition of organic matters which tends to be high in water polluted by sewage, and in the present study they were nil, aside from bore well water. Increased nitrate amounts in water causes different problems such as decreased oxygen level resulting in effects on aquatic life, plants and algae, and further can change normal haemoglobin to methaemoglobin [34]. Nitrites unreasonable presence in water presents a wellbeing danger due to their poisonous oxidizing power. Hanson and Grizzle [35] noticed the pernicious impact of nitrogenous mixes, particularly the presence of nitrites at 6mg/L on the channel catfish (*Ictalurus punctatus*). Nevertheless, they were nil except for bore well water. Despite the fact that chloride is less unsafe, it still gives unpleasant taste to the water, and damages the floral vegetation [36]. The chloride values of the present study indicated the corporation and bore well water to be potable. Fluoride content in water increases the resistivity of tooth enamel against acids which cause the initiation of tooth decay when its concentration becomes high, and when low it causes discolouration of teeth. Elevated fluoride levels also may cause skeletal damage and bone disease [37], but their values were within the limits. Sulphate is found in small quantities due to industrial or anthropogenic additions in the form of sulphate fertilizers. High concentration of sulphate may be due to oxidation of pyrite and mine drainage [38]. Sulphate is obtained from the disintegration of salts of sulphuric acid which are found plentifully in all water bodies which have an effect on the aquatic life. High phosphate content is an index of pollution that influences water quality, and causes muscle damage, breathing problem, and kidney failure [39]. Nonetheless, they were nil except for effluent water indicative of industrial effluents.

Entry of iron into the water body may be through the tinkering and electroplating shops, paint factory, electrical engineering works contributing to the increase in the heavy metal content. Iron is one of the key blood constituent in human and other living organisms, and an essential element for human nutrition and metabolism, yet in excess quantities results in toxic effect like hemochromatosis in tissues [29,34]. Iron content was recorded nil apart from bore well water which lie within the limits. Manganese is present as manganous ion in water and its high concentration may cause some adverse health effects [40], but in the present study their values were nil. Toxic metals are naturally found in the earth's crust throughout the ecosystem. Heavy metals in excess quantity have a negative impact on the immunocompetence, oxidative status and reproductive performance of birds. Developmental abnormalities were observed in embryos too with abnormal eyes, beaks, wings, legs, and feet [41]. It has been clearly established that metals enter the aquatic environment, and gets accumulated in the tissues of aquatic vertebrates and invertebrates, and they are instrumental in damaging the aquatic fauna [42]. The toxicity of a metal is dictated by numerous factors including concentration and duration of action, ambient temperature, oxygen content in water, pH, hardness of the water, and presence of compounds with which the metal may complex. Rise of water temperature, oxygen deficit, decrease of pH, and hardness usually enhance the metal toxicity for hydrobionts.

5. CONCLUSION

The reason behind waning nature of soil and water in this village might be due to location of industrial units. This study revealed that metal concentration in water was nil, yet significantly higher in soil at the site of the tannery locality than in the normal agricultural and residential areas. Metals accumulated in soil are adsorbed by vegetables and fruits that are eventually consumed by human and animals through the tropical food cycle. The metal parameters of soil act as significant pointers for ecological risk assessment seeking the attention of public towards safe guarding of flora and fauna biodiversity. Hence, it is recommended that suitable soil quality management is essential to avoid any further contamination. Future studies on soil and water analysis of other villages in Ranipet district would determine the quality of soil and water for biotic community.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sharpudin J, Pratheesh, B, Balakumar K, Tamilthendral V. Spatial variation and an investigation on soil quality in the vicinity of industrial area in Ranipet, Vellore. International Journal of Advanced Research Trends in Engineering and Technology. 2018; 5(5):50-60.
2. Ramesh K, Seetha K. Hydrochemical analysis of surface water and groundwater in tannery belt in and around Ranipet, Vellore district, Tamil Nadu, India. International Journal of

Research in Chemistry and Environment. 2013;3(3):36-47.
3. Rao GT, Rao VVSG, Ranganathan K. Hydrogeochemistry and groundwater quality assessment of Ranipet industrial area, Tamil Nadu, India. Journal of Earth System Science. 2013;122(3):855-867.
4. Venkatesan N, Asokan MA, Prabu SS, Giriraj M, Vanitha D. Study of ground water contamination at Tamil Nadu Chromate Chemicals Limited, Plant and its surrounding area in SIPCOT industrial complex in Ranipet in Vellore district, India. International Journal of Chem Tech Research. 2014;6(7):3651-3657.
5. Kotteeswaran M, Sundaresan S, Preethy R, Senthilkumar B. Analysis of some heavy metals in water, soil and fish from Pulliyankannu lake at Ranipet, Vellore dist., Tamil Nadu, India. International Journal of Pharmaceutical & Biological Archives. 2015; 6(2):32-36.
6. Ambiga K, Annadurai R. Valuation of groundwater susceptibility in and around Ranipet area using radical index, Vellore, Tamil Nadu, south India. Rasayan Journal of Chemistry. 2016;9(3):413-423.
7. Andiyappan K, Alagarsamy VAV, Abubacker TA. Contemporary status of heavy metal contamination in soils affected by tannery activities, Ranipet, south India. Oriental Journal of Chemistry. 2017;33(6):3092-3100.
8. Thangam TED, Kumar VN, Vasline YA. Remediation of chromium contamination in and around Tamil Nadu Chromate Chemicals Limited in SIPCOT industrial estate, Ranipet, Vellore district, Tamil Nadu, India. International Journal of Applied Engineering Research. 2018;13(7):4878-4883.
9. Kistan A, Kanchana V. Cr and Pb contamination in agricultural soil in two different seasons and three depth of the soil layer samples nearby tannery waste disposal zones at Ranipet, Vellore district in the southern India. International Journal of Pharmaceutical Sciences and Research. 2020;11(7):3469-3473.
10. SPSS. IBM SPSS statistics for windows, Version 22.0. Armonk, NY: IBM Corp; 2010.
11. Freeze AR, Cherry JA. Groundwater. Prentice-Hall, NJ; 1979.
12. Hem JD. Study and interpretation of chemical characteristics of natural waters, 3rd edn. US Geological Survey Water Supply Paper. 1989;2254.
13. Andrade E, Palacio HAQ, Souza IH, Leao RA, Guerreio MJ. Land use effects in groundwater composition of an alluvial aquifer by multivariate techniques. Environmental Research. 2008;106:170-177.
14. Walton WC. Groundwater resources evaluation. McGraw Hill Book Co, New York; 1970.
15. Smith P, Cotrufo MF, Rumpel C, Paustian K, Kuikman PJ, Elliott JA, McDowell R, Griffiths RI, Asakawa S, Bustamante M, House JI, Sobocká J, Harper R, Pan G, West PC, Gerber JS, Clark JM, Adhya T, Scholes RJ, Scholes MC. Biogeochemical cycles and biodiversity as key drivers of ecosystem services provided by soils. Soil. 2015;1:665-685.
16. Onder S, Dursun S, Gezgin S, Demirbas A. Determination of metal pollution in grass and soil of city centre green areas (Konya, Turkey). Polish Journal of Environmental Studies. 2007;16:145-154.
17. Sheeja JLP. Assessment of macro and micronutrients in soils from Mannargudi area, Thiruvarur district, Tamil Nadu, India. Research Journal of Chemical and Environmental Sciences. 2015;3(6):32-37.
18. Shivanna AM, Nagendrappa G. Chemical analysis of soil samples to evaluate the soil fertility status of selected command areas of three tanks in Tiptur taluk of Karnataka, India. IOSR Journal of Applied Chemistry. 2014;11(1):1-5.
19. Subha TJ, Rose GL. Physico-chemical parameters and fertility status in selected soils of Agastheeswaram, Kalkulam and Vilavancode taluk's of Kanyakumari district, Tamil Nadu, India: A study. Indian Journal of Advances in Chemical Science. 2016;4(4):386-393.
20. Raman N, Sathiyanarayanan D. Physico-chemical characteristics of soil influence of cation exchange capacity of soil in and around Chennai. Rasayan Journal of Chemistry. 2009;2(4):875-885.
21. Vijayakumar R, Arokiaraj A, Prasath MDP. Micronutrients status and their relation to soil characteristics of south-east coastal soils of India. International Journal of Research in Chemistry and Environment. 2011;1(1):147-150.
22. Sharma JC, Chaudhary K. Vertical distribution of micronutrient cations in relation to soil characteristics in lower Shiwaliks of Solan district in north-west Himalayas. Journal of the Indian Society of Soil Science. 2007;55:40-44.
23. Takkar PN, Nayyar VK, Bansal RL, Dwivedi RS, Manna MC. Annual progress report of ICAR coordinated micronutrient scheme 1996-97, PAU, Ludhiana; 1997.

24. Venkatramanan S, Chung SY, Lee SY, Namsik P. Assessment of river water quality via environmetric multivariate statistical tools and water quality index: A case study of Nakdong river basin, Korea. Carpathian Journal of Earth and Environmental Sciences. 2014;9(2):125-132.
25. Duran-Encalada JA, Paucar-Caceres A, Bandala ER, Wright GH. The impact of global climate change on water quantity and quality: A system dynamics approach to the U.S. Mexican transborder region. European Journal of Operational Research. 2016;1-16.
26. Ismaniza I, Idaliza MS. Analysis of heavy metals in water and fish (*Tilapia* sp.) samples from Tasik Mutiara, Puchong. Malaysian Journal of Analytical Sciences. 2012;16(3):346-352.
27. Elkady AA, Sweet ST, Wade TL, Andrew GA, Klein AG. Distribution and assessment of heavy metals in the aquatic environment of lake Manzala, Egypt. Ecological Indicators. 2015;58:445-457.
28. Dugdale SJ, Curry RA, St-Hilaire A, Andrews SN. Impact of future climate change on water temperature and thermal habitat for keystone fishes in the lower Saint John river, Canada. Water Resources Management. 2018;32(15):4853-4878.
29. Kumar A, Garg V. Heavy metal and physico-chemical characteristics of river Ganga from Rishikesh to Brijghat, India. Journal of Environment and Bio-Sciences. 2019;33(2):243-250.
30. Shyamala R, Shanthi M, Lalitha P. Physicochemical analysis of borewell water samples of Telungupalayam area in Coimbatore district, Tamil Nadu, India. European Journal of Chemistry. 2008;5(4):924-929.
31. Smith R. Alarm signals in fishes. Reviews in Fish Biology and Fisheries. 1992;2:33-63.
32. Buridi KR, Gedala RK. Study on determination of physicochemical parameters of ground water in industrial area of Pydibheemavaram, Vizianagaram district, Andhra Pradesh, India. Austin Journal of Public Health and Epidemiology. 2014;1(2):1-3.
33. Chapman D. Water quality assessments. SPON Chapman & Hall, London; 1996.
34. Sagar SS, Chavan RP, Patil CL, Shinde DN, Kekane SS. Physico-chemical parameters for testing of water-A review. International Journal of Chemical Studies. 2015;3(4):24-28.
35. Hanson LA, Grizzle JM. Nitrite-induced predisposition of channel catfish to bacterial diseases. Progressive Fish Culturist. 1985;47:98-101.
36. Sooraj MSA. Water quality analysis in Velacherry lake, Chennai – a review. International Journal of Pure and Applied Mathematics. 2018;119(16):4769-4774.
37. National Research Council. Fluoride in drinking water: A scientific review of EPA's standards. Washington DC. National Academies Press; 2006.
38. Meride Y, Ayenew B. Drinking water quality assessment and its effects on residents health in Wondo genet campus, Ethiopia. Environmental Systems Research. 2016;5:1-7.
39. Nyamangara J, Jeke N, Rurinda J. Long term nitrate and phosphate loading river water in the Upper Manyame catchment, Zimbabwe. Water SA. 2013;39(5):637-642.
40. Williams M, Todd GD, Roney N. Toxicological profile for manganese. U.S. Department of Health and Human Services. Public Health Service. Atlanta, Georgia; 2012.
41. Vermeulen A, Müller W, Matson KD, Tieleman BI, Bervoets L, Eens M. Sources of variation in innate immunity in great tit nestlings living along a metal pollution gradient: an individual-based approach. Science of the Total Environment. 2015;508:297-306.
42. Han BC, Jeng WL, Jeng MS, Kao LT, Meng PJ, Huang YL. Rock-shells (*Thais clavigera*) as an indicator of As, Cu, and Zn contamination on the Putai coast of the Black-Foot disease area in Taiwan. Archives of Environmental Contamination and Toxicology. 1997;32:456461.