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EVALUATION OF QUALITY OF GROUND WATER DUE TO TRACE ELEMENTS IN THE PROXIMITY OF RIVER NOYYAL, TIRUPPUR, SOUTH INDIA

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ABSTRACT

In this present investigation, the level of penetration of trace elements in and around the Noyyal river water was carried out. Trace metal concentrations of copper, cadmium, iron, lead, zinc, manganese and cobalt of groundwater samples of the study areawere determined using Atomic Absorption Spectrometry during different periods of pre-monsoon and post-monsoon of the year 2018 and 2019. The percolation of the polluted water from river Noyyal is found to be higher in the southern part when compared to northern part which may be attributed to the slope and differential soil characteristics. Spatial distribution map of most of the trace metals in the groundwater of the study area was found to be well within the permissible limit for irrigation.

KEY WORDS : Ground water, Trace elements, River Noyyal, Water quality.

INTRODUCTION

Metals are non-biodegradable and accumulative in nature. Elevated emissions and their deposition over time can lead to anomalous enrichment, causing metal contamination of the surface environment (Xiao *et al.,* 2018; Fikret *et al.,* 2020; Xu *et al.,* 2020). The prolonged presence of contaminants in the urban environment particularly in urban soils, and their close proximity to the human population can significantly amplify the exposure of the urban population to metals through inhalation, ingestion, and dermal contact (Malakar *et al.,* 2019; Tsering *et al*., 2019). A human health concern is usually associated with excessive exposures to metals that cause toxic effects to biological organisms, referred to as trace metals of environmental concern (Tudi *et al*., 2020; Kelly *et al*., 2020). These trace metals may include non-essential ones, such as Cd and Pb that can be toxic even at trace levels, and other indirect consequences of trace metal contamination of the urban environment include the subsequent migration of pollutants to receiving bodies of water through urban runoff, resulting in the trace metal

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enrichment of sediments (Zhang *et al.*, 2019). This may affect the quality of aquatic ecosystems and increase the body loadings of aquatic organisms through bio-accumulation and bio-magnification, potentially causing trace metal contamination of the food chain (Li *et al.,* 2019). Examining distribution, sources and contamination level of dissolved trace elements in natural waters is basic but important for pollution assessment and efficient management. Researchers were doing extensive studies in this area (Javed *et al.,* 2017).

Study Area

The study area is located in the central part of Tamil Nadu (latitude 11°06'19"N - 11°03'51"N and longitude 77°30'14"E - 77°47'52"E). The region is basically an agricultural area with paddy as the main crop. Major part of the region consists of complex Granitic Gneiss formation. Kankar and jointed gneissic formations are observed below the top soil. All the selected wells located in this region fall in the Charnockite formation. Because of the down through, the thickness of top soil is found to be more in the northern bank of River Noyyal than the southern bank. The influence of River Noyyal in the region is hïghly significant as it supports various tanks, lakes and is also the source for groundwater recharge. Noyyal is the major source for irrigation, drinking water and other activities of the people living on both sides of the river and even for people living beyond 3 km from the river. River Noyyal is a seasonal river and it originates from Vellingiri Hills in the Western Ghats of Coimbatore District. It flows through various districts and finallyjoins Cauvery River near Noyyal village. It flows over a distance of 175 kilometers. The catchment area of the river is 3.49 lakh hectares. Throughout its distance on both sides of the banks of river Noyyal, more than 100 villages are situated. River Noyyal passes through Tirupur, the textile town where the water gets polluted due to the indiscriminate discharge of effluents from industries located in this region.

Present Study

Keeping in view of the importance of the region and the constant addition of pollutants into the vital water source, detailed study of surface and ground water gains more significance. Twenty one sites were selected in the Noyyal River for surface water quality evaluation. Among these, 16 sites were selected in the upstream side of Orathupalayam Dam including the dam water and remaining 5 are at different zones away from the Dam corresponding to the groundwater sampling site. For groundwater quality evaluation, five zones were selected from the Orathupalayam dam to downstream side. In each zone, five wells were selected on the northern and southern banks of the river. Totally 50 wells were selected for groundwater quality monitoring.

Sampling Design

The sampling design includes 21 River water, 50 groundwater in a grid pattern during pre-monsoon and post-monsoon. Samples were collected during July 2018 (pre-monsoon); December 2018 (post-monsoon); July 2019 (pre-monsoon) and December 2019 (post-monsoon). The study area is chosen in the eastern part of the Orathagadam dam and the groundwater samples were collected in a grid pattern at both northern and southern part of river Noyyal. A stratified, random sampling design was chosen and as many sites as possible were sampled to provide sufficient coverage of the study area. The aim of the study was to identify and evaluate the level of penetration of polluted surface water on the adjacent aquifers of the region.

Methodology

The Methodology adopted in the analysis decides the precision and accuracy of the analytical results (Fig. 1). Analysis depends critically on the acquisition of a sample that is truly representative of the material to be analyzed. There are serious problems that arise from significant contamination during sampling and storage due to the presence of extraneous materials, including sampling device and storage vessel and, equally, a serious risk of loss of analyte due to adsorption, vaporization, biological, chemical and other physical changes. However, sampling is a problem that is common to all major and trace element procedures whether they be volumetric, spectro-photochemical or electroanalytical. For this reason, sampling techniques are dealt with in detail. In order to obtain reliable and representative result, standard analytical procedures were adopted. The samples were analyzed immediately, considering the fact that shorter the time that elapses between collection of the sample and its analysis, the more dependable will be the analytical results.

Collection of Water Samples

Various stations along the river course and groundwater were selected and the water samples were collected during the months of July and December representing the pre and post monsoon seasons, respectively. The pre-cleaned polyethylene bottles were used for collecting all the water samples from the wells and river. Suitable preservatives were added immediately after the collection and analyzed for various constituents mentioned below:

- Major ions (Ca, Mg, Na, K, CO_3, HCO_3, SO_4, Cl, NO_3, NO_2, SiO_2).
- Minor and trace metals (Fe, Mn, Cr, Cu, Pb, Zn, As and Co) by Atomic Absorption Spectrometry (AAS).

Geographical Information System

Geographic Information System (GIS) is computer software capable of assembling, storing, manipulating, analyzing and displaying the geographically referenced information. This system contains both data identified according to their locations; graphic and non-graphic data is used extensively to prepare maps, analyzing data, creation of contours, measuring areas and finally creation of complete database for further research. GIS is a rapidly growing technology that incorporates graphical features with tabular data in order to assess real-world problems. The key intentionof this technology is Geography - this usually means that the data (or at least some proportion of the data) is spatial, in other words, data that is in some way referenced to locations on the earth. Attribute data is generally defined as additional information, which can then be tied to spatial data.

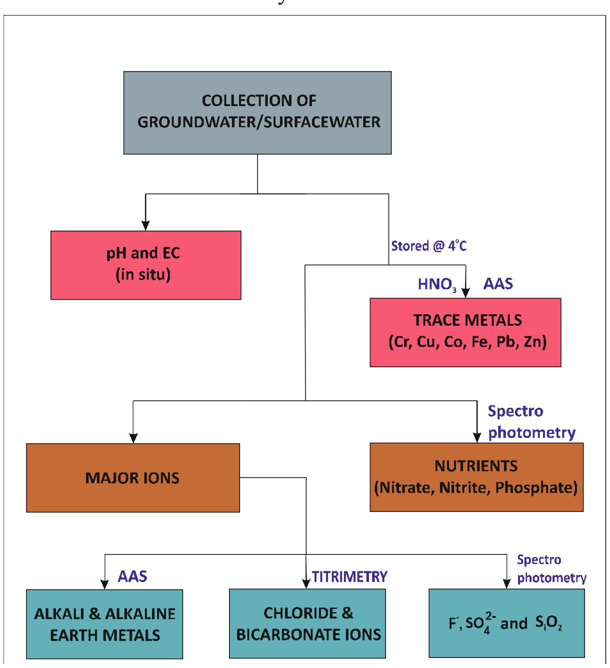

Fig. 1. Methodology

RESULTS AND DISCUSSION

Trace metal concentrations of copper, cadmium, iron, lead, zinc, manganese and cobalt of groundwater of the study area during different periodswere determined in July 2018, July 2019, December 2018 and December 2019. The following are the observations:

Copper

During pre-monsoon, the concentration of Cu ranges from 0.016 to 0.113 mg/l and from 0.014 to 0.101 mg/l with an average of 0.05mg/l and 0.045 mg/l during July 2018 and July 2019 respectively. Spatial distribution map of Copper illustrates (Fig. 2a-b) that wells pertaining to the 4th zone show higher concentration of Cu in the range of 0.074-0.094. Wells in the southern part of the study area illustrated higher content of Cu than in the northern part. Copper concentration in the groundwater was

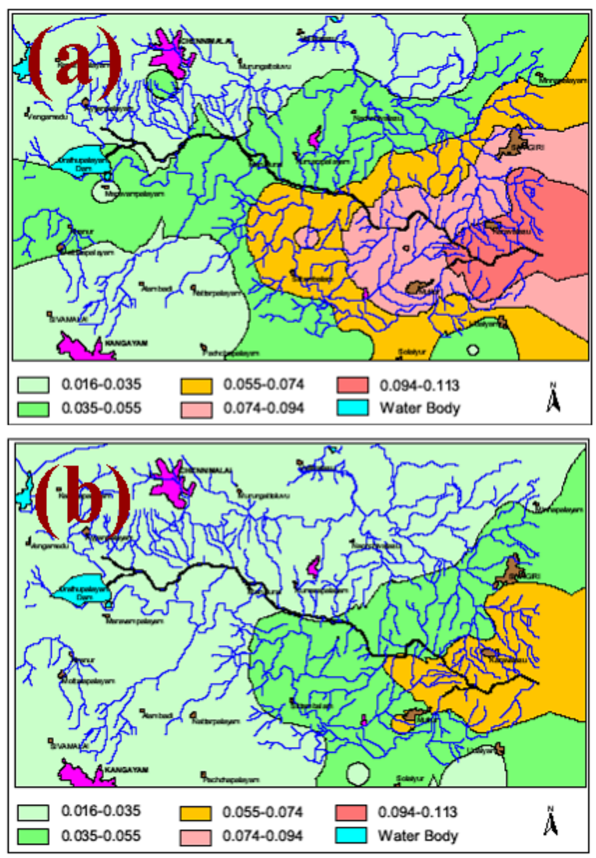

Fig. 2. Shaded contour map of copper (ppm) in (a) July 2018 and (b) December 2018

found to decrease in July 2019 compared to the values of July 2018, but the spatial distribution pattern demonstrate similarities except in case of wells belonging to zone 1. During post-monsoon, copper values ranging from 0.01 to 0.074mg/l and from 0.006 to 0.077 mg/l with an average of 0.032 mg/l and 0.022 mg/l during December 2018 and December 2019 respectively. Spatial distribution diagramclearly illustrates marked difference in the composition of copper in the wells of the study area. The concentration of Cu is found to decrease in all the zones especially in zone 1 and zone 2. Results clearly illustrate that the effect of monsoon is highly significant with respect to copper ions in these waters. It is found that no well have Cu values greater than the BIS allowed limit of 1.5 mg/l.

Cadmium

During pre-monsoon, the concentration of Cd ranges from 0.008 to 0.048 mg/l and from 0.007 to 0.052 mg/l with an average of 0.021 mg/l and 0.018 mg/l during July 2018 and July 2019 respectively. Spatial distribution map of cadmium illustratesthat wells pertaining to the 1^{st} layer except at 5^{th} zone show higher concentration of Cd in the range of 0.034-0.040. Most of the wells both in southern and northern part of River Noyyal show values exceeding the permissible limit. Wells in the southern part of the study area illustrated higher content of Cd than in northern part. Cadmium concentration in the groundwater was found to decrease in July 2019 when compared to the values of July 2018. During post-monsoon, Cadmium values range from 0.005 to 0.034 mg/l and from 0.004 to 0.035 mg/l with an average of 0.015 mg/l and 0.012 mg/l during December 2018 and December 2019 respectively. About 50% of the wells are found to have values higher than the permissible limit imposed by BIS. Spatial distribution diagram clearly illustrated marked difference in the composition of cadmium in the wells of the study area. The concentration of Cd is found to decrease in all the zones when compared to pre-monsoon. Results clearly illustrate that the effect of monsoon is highly significant with respect to cadmium ions in these waters. The percolation of polluted water from river Noyyal to the aquifers is found to be high in the southern part when compared to the northern part of the study area.

Lead

During pre-monsoon, the concentration of Pb ranges from 0.083 to 0.532 mg/l and from 0.062 to 0.400 mg/l with an average of 0.270 mg/l and 0.203 mg/l during July 2018 and July 2019 respectively. Spatial distribution map of lead illustrates (Fig. 3a-b) that wells pertaining to 4^{th} and 5^{th} zone show higher concentration of Pb in the range of 0.442-0.532. Most of the wells both in the southern and northern part of River Noyyal show values exceeding the permissible limit. Wells in the southern part of the study area illustrated higher content of Pb than in the northern part. Lead concentration in the groundwater was found to decrease in July 2019 compared to the values of July 2018. During post-monsoon, Lead values range from 0.065 to 0.358 mg/l and from 0.044 to 0.242 mg/l with an average of 0.186 mg/l and 0.134 mg/l during December 2018 and December 2019 respectively. Though seasonal effect significantly reduced the concentration of Pb in these waters, most of the samples show values higher than the permissible limit. Spatial distribution diagram clearly illustrates marked difference in the composition of lead in the wells of the study area. The concentration of Pb is found to decrease in all the zones when compared to pre-monsoon. Results clearly illustrate that the effect of

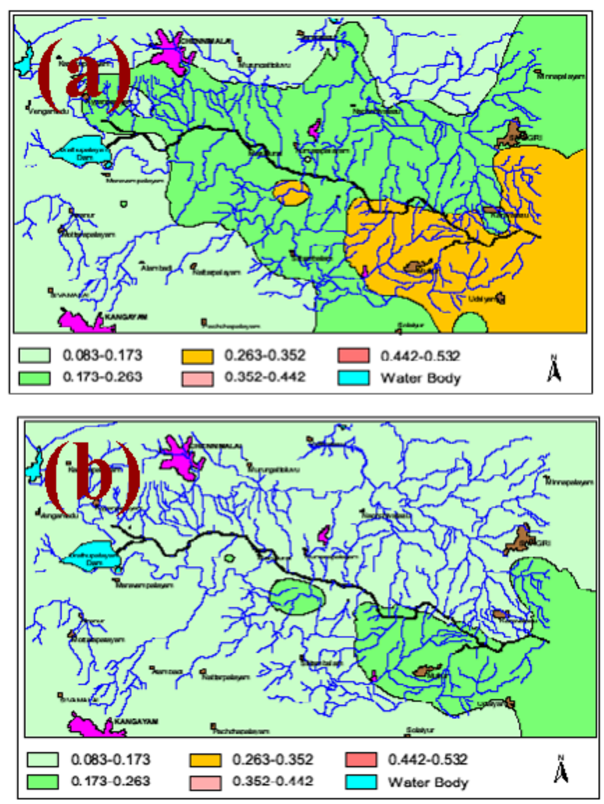

Fig. 3. Shaded contour map of lead (ppm) in (a) July 2018 and (b) December 2018

monsoon is significant with respect to Lead in these waters.

Iron

During pre-monsoon, the concentration of Fe ranges from 0.224 to 0.740 mg/l and from 0.242 to 0.798 mg/l with an average of 0.468 mg/l and 0.505 mg/l during July 2018 and July 2019 respectively. Spatial distribution map of iron illustrates that wells pertaining to zone 1 and zone 3 shows higher concentration of Fe in the range of 0.637-0.740 mg/l. Wells belonging to the 3rd to 5th layer of Zone 1 shows higher value which must be attributed to the geogenic origin since the 1st and 2nd layer of wells which are lying near to the polluted river shows lower values. Compared to the values of July 2018, about 10 wells in July 2019 shows higher values in the range of 0.637-0.740 mg/l. Most of the wells both in the southern and northern part of River Noyyal show values well within the permissible limit. Wells in the southern part of the study area illustrated higher content of Fe than in the northern part. During post-monsoon, Iron values range from 0.160 to 0.562 mg/l and from 0.161 to 0.563 mg/l with an average of 0.327 mg/l and 0.337 mg/l during December 2018 and December 2019 respectively. Spatial distribution diagram clearly illustrated marked difference in the composition of iron in the wells when compared to the pre-monsoon values of the study area. The concentration of Fe is found to decrease in all the zones when compared to pre-monsoon. Results clearly illustrate that the effect of monsoon is significant with respect to iron in these waters.

Manganese

During pre-monsoon, the concentration of Mn ranges from 0.254 to 0.852 mg/l and from 0.276 to 0.926 mg/l with an average of 0.561 mg/l and 0.610 mg/l during July 2018 and July 2019 respectively. Spatial distribution map of Manganese illustrates that wells pertaining to zone 2, zone 4 and zone 5 show higher concentration of Mn in the range of 0.732-0.852 mg/l. Most of the wells belonging to the 5 layers under study show values higher than the permissible limit of 0.3 mg/l. Compared to the values of July 2018, about 8 wells in July 2019 show higher values in the range of 0.732-0.852 mg/l. During both pre-monsoon periods, it is observed that wells in the southern part of the study area illustrated higher content of Mn than in the northern part. During post-monsoon, Manganese values range from 0.158 to 0.555 mg/l and from 0.193 to 0.683 mg/l with an average of 0.362 mg/l and 0.424 mg/l during December 2018 and December 2019 respectively. Spatial distribution diagram clearly illustrates marked difference in the composition of manganese in the wells compared to the pre-monsoon values of the study area. During post-monsoon, the concentration of Mn is found to decrease in all the zones. Results clearly illustrate that the effect of monsoon is significant with respect to Manganese in these waters.

Zinc

During pre-monsoon, the concentration of Zn ranges from 0.018 to 0.095 mg/l and from 0.014 to 0.074 mg/l with an average of 0.056 mg/l and 0.044 mg/L during July 2018 and July 2019 respectively. Spatial distribution map of Zinc illustrates (Fig. 4a-b) that wells pertaining to zone 2-5 shows higher concentration of Zn in the range of 0.080-0.095 mg/l. Most of the wells both in the southern and northern part of river Noyyal show values well within the permissible limit. Compared to the values of July 2018, it is observed that there is a considerable decrease in the concentration of Zn during July 2019. Most of the wells fall in the range of 0.049-0.064 mg/l. The distribution of the concentration of Zinc in the wells lying in the northern and southern part of the study area is

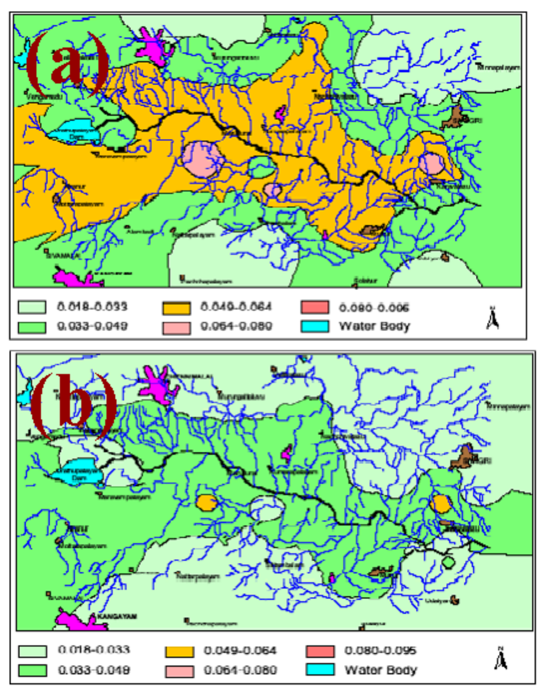

Fig. 4. Shaded contour map of zinc (ppm) in (a) July 2018 and (b) December 2018

almost equal. During post-monsoon, Zinc values ranging from 0.011 to 0.061 mg/l and from 0.010 to 0.055 mg/l with an average of 0.036 mg/l and 0.030 mg/l during December 2018 and December 2019 respectively. Spatial distribution diagram clearly illustrates that precipitation during the monsoon period diluted the concentration of Zinc in the wells when compared to the pre-monsoon values of the study area. The concentration of Zn is found to decrease in all the zones when compared to pre-monsoon. Results clearly illustrate that the effect of monsoon is significant with respect to Zinc in these waters.

Cobalt

During pre-monsoon, the concentration of Co ranges from 0.025 to 0.153 mg/l and from 0.018 to 0.110 mg/l with an average of 0.074 mg/l and 0.053 mg/l during July 2018 and July 2019 respectively. Spatial distribution map of Cobalt illustrates that wells pertaining to zone 5 show higher concentration of Co in the range of 0.127-0.153 mg/l. About 90% of the wells exceed the permissible value of 0.05% in the study area. Contour plots of July 2019 also show that the wells in the zone 5 records higher concentration of Co in the range of 0.127-0.153mg/L. It is observed that there was a considerable decrease in the concentration of Co during this period. Wells in the southern part of the study area show higher content of Co than in the northern part. During post-monsoon, Cobalt values ranging from 0.016 to 0.100 mg/l and from 0.013 to 0.077 mg/l with an average of 0.048 mg/l and 0.037 mg/l during December 2018 and December 2019 respectively. Spatial distribution diagram clearly illustrated marked difference in the composition of Cobalt in the wells when compared to the pre-monsoon values of the study area. The concentration of Co is found to decrease in all the zones when compared to pre-monsoon. Results clearly illustrate that the effect of monsoon is significant with respect to Cobalt in these waters.

Water Quality for irrigation

Neither the nutrient value nor the toxicity of trace elements in irrigation water can be ignored. Non-essential heavy metals of particular concern to surface water systems are cadmium, chromium, mercury, lead, arsenic, and antimony. The average values of Copper during pre-monsoon and post-monsoon are 0.048 and 0.027 mg/l respectively. The permissible limit of Cu for irrigation is 0.2 and 1.0 mg/l for long term and short term use. The results clearly shows that the copper content in these groundwater is within the safe permissible limits and suitable for irrigation with respect to this metal. Lead (Pb) varies from 0.24 to 0.16 mg/l during pre-monsoon and post-monsoon periods respectively. Pb above the limit of 5.0 mg/l inhibits plant cell growth. The study area is found to be very safe with regard to this metal since the estimated values are well within the permissible limit. The mean values of Cadmium (Cd) during pre-monsoon and post-monsoon are 0.019 and 0.013 mg/l respectively. The permissible limit of Cd for irrigation is 0.01 and 0.05 mg/l for long term and short term use. Most of the values during both the seasons exceed the permissible limit for long term use but found to be safe for short term use of these waters for irrigation with respect to this metal. Zinc (Zn) varies from 0.045 to 0.033 mg/l during pre-monsoon and post-monsoon periods respectively. These results show that the water is within the safe limits for irrigation use with respect to this metal. In the case of Cobalt (Co), the average values during pre-monsoon and post-monsoon are 0.063 and 0.042 mg/l. The permissible limit of Co for irrigation is 0.05 and 5.0 mg/l for long term and short term use. Most of the values during both the seasons exceed the permissible limit for long term use but found to be safe for short term use of this water for irrigation with respect to this metal.

CONCLUSION

Hydrochemistry and Spatio-temporal variations of trace metals in groundwater of the study area have been studied in detail and the research findings are summarized below:

(1) Concentration of copper was found to be low even in the 1st layer which is located 500m from the polluted River Noyyal. The low level of copper found in these water samples may be due to the precipitation as ferrite compounds since copper readily forms intermetallic compounds mainly with iron which are sparingly soluble in water. Copper concentration in the groundwater was found to decrease in July 2019 when compared to the values of July 2018 but the spatial distribution pattern demonstrates similarities.

(2) Contour plots of Cadmium illustrates that wells pertaining to the 1stlayer shows higher concentration of Cd. Most of the wells both in

the southern and northern part of River Noyyal show values exceeding the permissible limit. Wells in the southern part of the study area illustrated higher content of Cd than in the northern part. Spatial distribution diagram of pre-monsoon and post-monsoon clearly illustrated marked difference in the composition of cadmium in the wells of the study area. Results clearly illustrate that the effect of monsoon is highly significant with respect to cadmium ions in these waters.

(3) Spatial distribution map of lead illustrates that wells pertaining to 4th and 5th zone shows higher concentration. Most of the wells both in the southern and northern part of River Noyyal show values exceeding the permissible limit. Lead concentration in the groundwater was found to decrease in July 2019 when compared to the values of July 2018. Though seasonal effect have significantly reduced the concentration of Pb in these waters, but still most of the samples show values higher than the permissible limit. The percolation of polluted water from River Noyyal to the aquifers is found to be high in the southern part when compared to the northern part of the study area.

(4) Spatial distribution map of Iron illustrates that wells pertaining to zone 1 and zone 3 shows higher concentration. Wells belonging to the 3rd, 4th and 5th layer of Zone 1 shows higher value which must be attributed to the geogenic origin since the 1st and 2nd layer of wells which are lying near to the polluted river shows lower values. Most of the wells both in the southern and northern part of River Noyyal show values well within the permissible limit. Wells in the southern part of the study area illustrated higher content of Fe than in the northern part. During post-monsoon, the concentration of Fe is found to decrease in all the zones. Results clearly illustrate that the effect of monsoon is significant with respect to iron in these waters.

(5) Most of the wells belonging to all the 5 layers under study show Manganese values higher than the permissible limit. During both pre-monsoon periods, it is observed that wells in the southern part of the study area illustrated higher content of Mn than in the northern part. Spatial distribution diagram of post-monsoon clearly illustrates marked difference in the composition of Manganese in the wells when compared to the pre-monsoon values of the study area.

(6) Spatial distribution map of Zn illustrates that wells pertaining to zone 2 to 5 show higher concentration of Zn. Most of the wells both in the southern and northern part of river Noyyal show values well within the permissible limit. Compared to the values of July 2018, it is observed that there is a considerable decrease in the concentration of Zn during July 2019. Spatial distribution diagram clearly illustrates that precipitation during the monsoon period diluted the concentration of Zn in the wells when compared to the pre-monsoon values of the study area.

(7) Spatial distribution map of Cobalt illustrates that wells belonging to almost all the layers show higher values. About 90% of the wells exceed the permissible value of 0.05% in the study area. Wells in the southern part of the study area illustrated higher content of Co than in the northern part. During post-monsoon, the concentration of Co is found to decrease in all the zones. Results clearly illustrate that the effect of monsoon is significant with respect to Cobalt in these waters.

(8) The percolation of the polluted water from River Noyyal is found to be higher in the southern part when compared to the northern part which may be attributed to the slope and differential soil characteristics.

(9) Most of the trace metals in the groundwater of the study area are found to be well within the permissible limit for irrigation.

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