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Dye Industries are a Threat to the Environment: An Assessment of Groundwater Characteristics

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Abstract: Every day, it becomes more difficult to find water. The main factor causing water body contamination is human activity. Groundwater becomes contaminated when improperly treated waste water from industries and other sources gets mixed with it. The primary objective of this initiative is to treat water that has been contaminated by toxic substances. The study's focus is on the process of eliminating additional compounds such as sulphate, nitrate, phenol, fluoride, mineral oil, calcium, and turbidity. The usefulness of ground water for specific uses depends on its chemistry, physical characteristics, and bacterial makeup. The groundwater's pH, fluoride, nitrate, sulphate, turbidity, hardness, phenol, and other characteristics were all measured. The treatments took into account aeration and sedimentation. The water is then recommended as safe for household and agricultural purposes.

Key words: Groundwater, contamination, treatment, industrial effluents, sustainable, economical.

Introduction

Water is essential for all living beings. Between 25 and 40% of the world's drinking water is produced via drilled and dug wells. Water that is present below the ground's surface has saturated the pore space of the ground. Farmers utilise groundwater to irrigate crops, and industries use it to make products that we use on a daily basis. Groundwater is typically clean, but occasionally it can become polluted or contaminated due to human activities or other environmental factors (Venkatesan & Subramani, 2016). Groundwater will never again be potable, despite the fact that the quantity of contamination caused by diverse industrial effluents, the environment, and anthropogenic activities has significantly decreased.

To dye, rinse, and further process textiles, the textile industry needs a lot of freshwater. When regulations are tightened and the cost of freshwater rises, wastewater reclamation becomes more and more attractive (Van der Bruggen et al., 2001). To gauge the level of pollution and the range of groundwater pollution rates, an index of water quality was developed (Adhikary et al., 2010; Hui et al., 2021; Stefanakis et al., 2017; Verma et al., 2014). It is useful for examining how groundwater quality is impacted by dye industry wastewater (Ranjan et al., 2013). Studies on cleaner production assessment were carried out in a textile facility that produces wool and acrylic fibres before dying them.

The study has attempted to recognise the precise amounts of consumption, emissions, and waste generation in various industries. Wool yarn washing and softening process waste water from hank dyeing machines can be combined with other process fluids for reuse in the same or different processes, or utilised immediately in tank washings (Ozturk et al., 2015).

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Physical, chemical, biological, advanced oxidation and electrochemical treatment techniques are used to treat industrial wastewater. Traditional biological treatment techniques, which are still widely used, are time-consuming, space-intensive, and inadequate for dealing with wastewater that contains dangerous compounds. Advanced oxidation techniques are frequently employed to produce high purity grade water, which results in large treatment expenses. Chemical coagulation takes a long time and produces a lot of sludge (Khandegar & Saroha, 2013).

A variety of human activities, as well as natural sources, can contaminate groundwater. Ground water contamination can be caused by residential, municipal, commercial, industrial, and even agricultural operations (Venkatesan & Subramani, 2018). Activities above and below the land surface, such as the release of dye effluents from industrial sources, can result in groundwater contamination. It is commonly known that rapid industrialisation, especially in developing countries, has a detrimental effect on both the quantity and quality of groundwater. Since groundwater is the main supply of drinking water, it is crucial to assess its quality. Using numerical modelling, chemical analysis, and statistical analysis, the current condition has been assessed (Ranjan et al., 2013). There are many reasons why groundwater becomes contaminated. Some of them include negligent human deposition, petrol spills and other dangerous fluids getting into subterranean storage tanks and contaminating groundwater sources, as well as pollution getting into groundwater through poorly built landfills or septic systems (Johnson et al., 1991). The features of water that call for ongoing monitoring are turbidity, sulphate, nitrate and fluoride. The highlighted treatment methods are sedimentation and aeration.

Sedimentation is a physical water treatment method that uses gravity to remove suspended particles from water. In the quiet waters of lakes and seas, sedimentation naturally takes place to remove solid particles that are entrained by the turbulence of moving water. In order to remove dissolved gases and oxidise dissolved metals like iron, manganese, and volatile organic compounds, aeration brings water and air into close proximity. Frequent aeration is the treatment plant's first important step (Azeem Khalid, 2008; Bhadra et al., 2013; Lee et al., 2010; Sharma & Kumar, 2020). The review will be used to assess the groundwater samples collected from the selected research area, identify any potential sources of pollution, and, if necessary, recommend suitable treatment options to stop residents from drinking contaminated water.

Experimental Section

Study Area

Nemili is a town in the Vellore district of Tamil Nadu. It is known as one of the most polluted cities in India. There are over 240 tanneries in and around the city (Gowd & Govil, 2008). This area has a high prevalence of asthma, skin disorders, and other occupational ailments. It was determined to use this area as a research area to examine how the chemicals used in tanneries affect groundwater as a result (Figure 1). Industrial garbage is routinely disposed of into the Kosasthalaiyar River after treatment.

Preliminary Survey

Four areas surrounding the Nemili textile industry, each one kilometre from the others, were the subjects of a preliminary survey. One kilometre away from the industry in each of the four directions are designated sample collection sites. To determine the preferred type of water among residents in and around the study area, a general survey was conducted (Figure 2). The survey was conducted with the help of a questionnaire. The survey was completed by 150 people. As a result, it was discovered that they often use either well water or bore water. The majority of residents consume untreated water. The percentage of people who boil their water before consuming it is only 10%.

Sample Collection

Water samples are collected from four different residential sites at a distance of 1 km from the selected industry, and they are displayed in Table 1 with the water type (Figure 3). The water sample collection is kept in 2-litre containers. It is maintained inside a thermocol box at a temperature of 40°C to 60°C. The water sample collection is done using two categories. The groundwater samples taken from the locals are split into three groups: SG1, SG2, and SG3. These 20 samples' physical and chemical characteristics are looked at. After analysis, the samples are processed. The treatment techniques include filtration, sedimentation, and aeration. The properties of samples of the treated water are evaluated. In order to identify the source of contamination, surface water samples from the Kosasthalaiyar River are collected from the selected study location. There are four categories for the samples that were collected: SR1, SR2, SR3, and SR4. The 20 collected samples were evaluated in a lab to ascertain their properties. It is analysed to see how it contributed to groundwater contamination in the selected research

AREA	GROUNDWATER DEPTH (FEET)	TYPE OF WATER
Nemili (S1)	110	Salty water
Kandigai (S2)	95	Salty water
Kuppam (S3)	95	Salty water
Parukur (S4)	100	Salty water

Figure 1: Location map (*Source*: Google), study area and its water type.

Questionnaire

1. What is the source of water?
   a) Well b) Bore c) Metro
2. Do you have an RO Unit?
   a) Yes b) No
3. Does your water taste good?
   a) Yes b) No
4. Do you like to continue the same?
   a) Yes b) No
5. Do you think any treatment is needed for the drinking water?
   a) Yes b) No

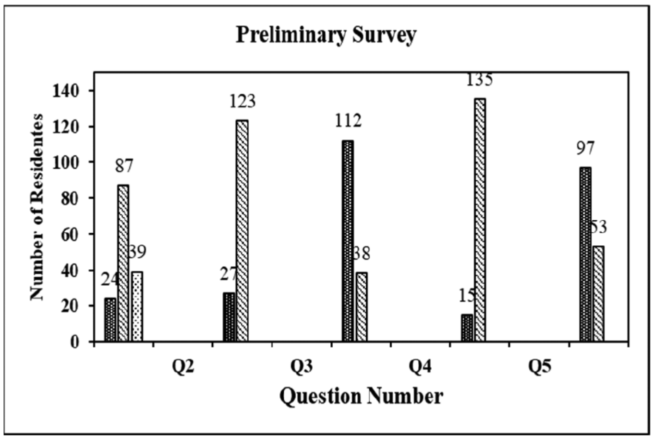

Figure 2: Preliminary survey on water quality.

Ground Water Samples	Number of Samples	SG After Treatment	Number of Samples	River Water Samples	Number of Samples
SG1	5	SG1 - AR	5	SR1	5
SG2	5	SG2 - AR	5	SR2	5
SG3	5	SG3 - AR	5	SR3	5
SG4	5	SG3 - AR	5	SR4	5

Figure 3: Water sample collected and its nomenclature.

Table 1: Experimental result of groundwater samples

Parameters	*SG1*	*SG2*	*SG3*	*SG4*	*Standard value*	*Comparison*
Colour (Hazen)	1	4	4	3	5	Low
Turbidity (NTU)	5.2	3	4	3.2	10-25	Low
Sulphates (mg/L)	123	117	130	110	150-400	Low
Nitrate (mg/L)	4.6	31	27	20	45	Low
Fluoride (mg/L)	0.18	0.4	0.29	0.22	0.6-1.2	Low
Calcium (mg/L)	236	297	243	211	75-200	High
Phenols (mg/L)	0.005	0.005	0.005	0.005	0.001-0.002	High
Mineral Oil (ppm)	0.24	0.25	0.21	0.23	0.01	High
Hardness (mg/L)	986	1096	852	700	300-600	High

area. Turbidity and colour are two physical factors that are taken into account for analysis. pH, hardness, chloride, calcium, magnesium, sulphate, phenolic compounds, nitrate, fluoride, and mineral oil are the chemical parameters taken into account for analysis. The samples' testing findings are contrasted with the Indian Standard Specification for Drinking Water (Da'ana et al., 2021).

Result and Discussion

Turbidity and colour are two physical factors that are taken into account for analysis. pH, hardness, chloride, calcium, magnesium, sulphate, phenolic compounds, nitrate, fluoride, and mineral oil are the chemical parameters taken into account for analysis. The samples' testing findings are contrasted with the Indian Standard Specification for Drinking Water.

The experimental findings for samples SG1, SG2, SG3, and SG4 are listed in Table 1. According to the inspection of the test samples, some of the qualities are below the permitted level and some are above the allowable limit. Among the qualities that are below the required level are colour, turbidity, sulphates, nitrates, and fluorides. Customers would not be harmed if the physical qualities of colour and turbidity are within reasonable bounds and can be easily adjusted. Water must be kept within the permissible range because it naturally includes sulphates, nitrates, and fluoride. Colon cancer, tooth decay, and diarrhoea may all be serious health risks if present in excess of what is permitted. If it falls below the permissible level, consumers won't be able to maintain their health because there aren't enough minerals. Hence, before ingestion, the water samples must be treated. The characteristics that go above what is permitted are hardness, calcium, phenol, and mineral oils. The taste of the water is altered by all of these additional components, making it unpleasant to drink (Simonović et al., 2009).

Figure 4 makes it clear that, based on the analysis of test samples, the quality of the groundwater does not fall within acceptable limits. As a result, we need to identify the reasons for water quality variations. The nature of the groundwater may be affected by industrial effluents and the outcome of soil strata. Groundwater properties like calcium and hardness are impacted by industrial effluents. Moreover, the condition of the soil impacts how water behaves. The groundwater may be contaminated by the effluents released by the nearby industry because it has been there for a long time. A prophylactic treatment should be used to avoid health problems. As a result, simple preparatory processes like sedimentation, aeration, and oxidation can be used during the treatment process.

Table 2 displays the experimental outcomes for the samples that underwent treatment. Filtration, aeration, sedimentation, and boiling are the treatment techniques used. The experimental results unmistakably demonstrate that it is possible to alter the attributes of treated groundwater samples so that they are nearly equal to those listed in the IS Specifications for drinking water. In order to avoid eventual health problems like diarrhoea, tooth decay, colon cancer, skin cancer, etc., it is urged that residents of the research region treat the bore or well water they use before consuming it. The majority of those who participated in the preliminary survey and reside in the study region complained about the bore or well water's flavour. The cause could be an

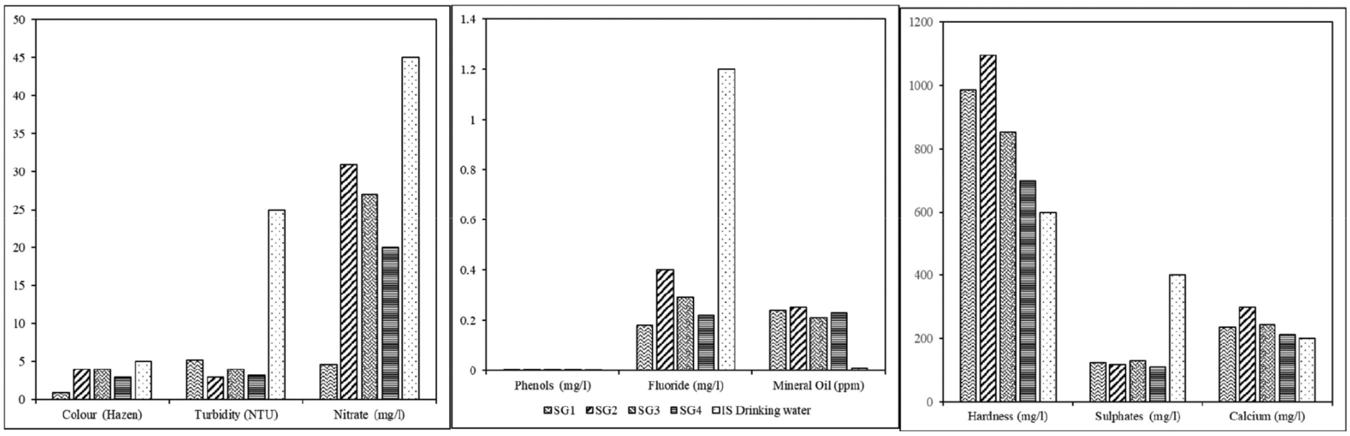

Figure 4: Properties of drinking water samples collected from the residents.

Table 2: Experimental results of groundwater samples after treatment

Parameters	*SG1 - AR*	*SG2 - AR*	*SG3 - AR*	*SG4 - AR*	*IS standards*
Colour (Hazen)	5	5	5	5	5
Turbidity (NTU)	10.4	11	18	20	10-25
Nitrate (mg/L)	48.1	46.2	45.9	44.5	45
Phenols (mg/L)	0.001	0.002	0.002	0.001	0.001-0.002
Fluoride (mg/L)	0.7	0.6	0.9	1	0.6-1.2
Mineral Oil (ppm)	0.01	0.01	0.03	0.02	0.01
Hardness (mg/L)	598	487	547	550	300-600
Sulphates (mg/L)	159	152	168	163	150-400
Calcium (mg/L)	196	150	194	187	75-200

excess of phenol, calcium, mineral oils, and hardness (Ali et al., 2019).

According to the testing results depicted in Figure 5, the characteristics such as phenol, calcium, mineral oil, and hardness are produced up to the standard values as per IS Specification after treatment. As a result, with the proper treatment, groundwater's flavour can be improved and its quality can be raised to a point where it is safe to drink without causing any health risks. The proposed course of treatment may not be very expensive because the suggested therapeutic approaches are so simple. Also, the treatment techniques indicated might not use much energy, making the procedure sustainable and reasonably priced.

A comparison of the characteristics of groundwater samples both before and after treatment is shown in Figure 6. This graph will demonstrate how the sample's characteristics, which weren't exactly as specified prior to treatment, could be brought into compliance with the requirements by appropriate treatment.

In order to identify the root cause of groundwater pollution, surface water samples from the study area were meant to be collected and examined. The results of the water sample investigations are shown in Table 3. Examining test samples has shown that most of their characteristics are higher than the specified permitted limits. It is accurate to argue that external causes influence surface water characteristics. The majority of the investigated industries may be considered a source of surface water contamination because they have been around for a while (Li et al., 2021). Except colour and nitrate, all of the other evaluation factors are above the permitted limits. It is therefore noticeable that the surface water sources are contaminated by the effluents released by the industries situated in the research region (Al-Sudani, 2019; Van Dijk et al., 2019).

These pollutants may seep into the soil because most of the features have exceeded the permissible limits. Due to soil's susceptibility to infiltration, bodies of surface water surroundings and the groundwater beneath

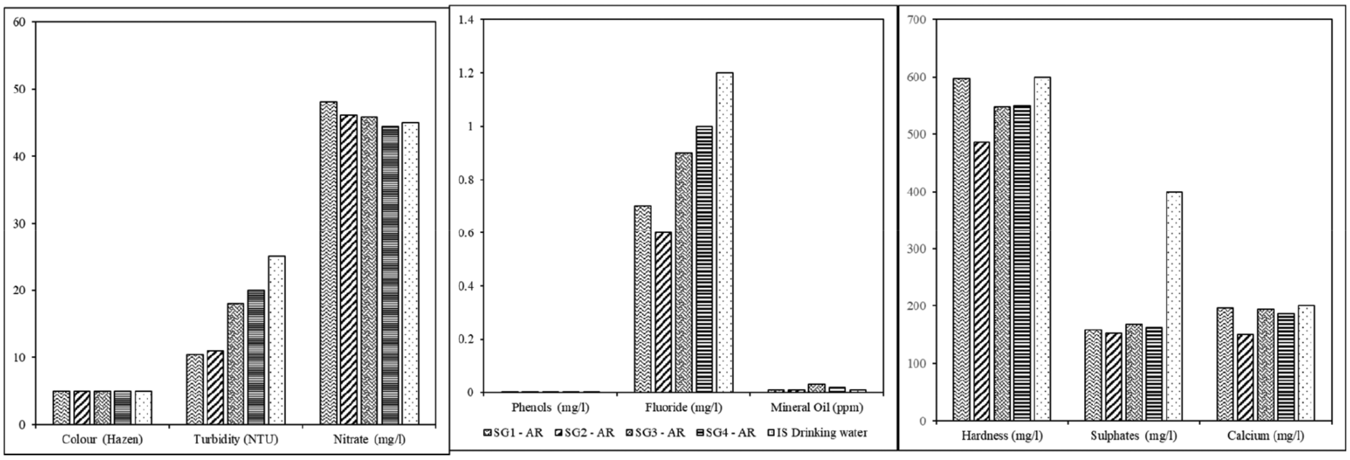

Figure 5: Properties of drinking water samples collected from the residents after treatment.

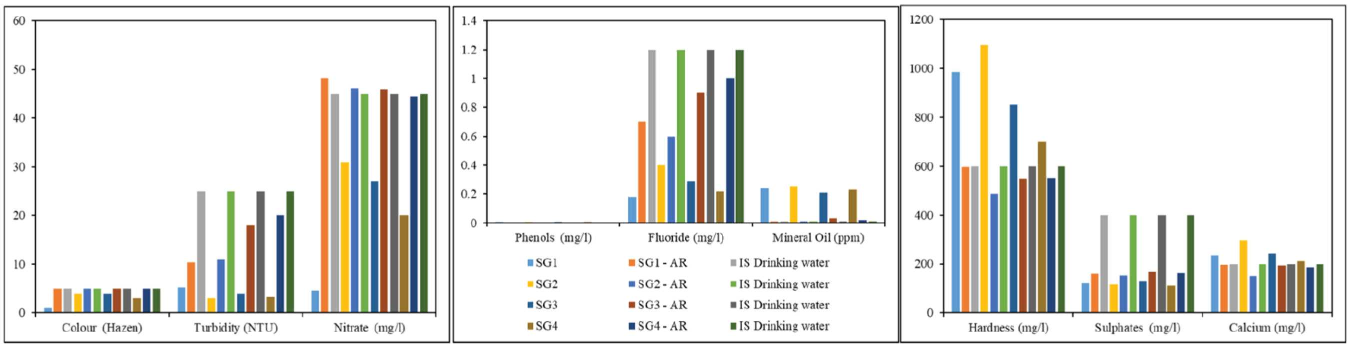

Figure 6: Comparison of properties of drinking water samples collected from the residents and after treatment with standards.

Table 3: Characteristics of surface water samples from Kosasthalaiyar river

Parameters	*SR1*	*SR2*	*SR3*	*SR4*	*Standard value*	*Comparison*
Colour (Hazen)	1	3	1	1	5	Low
Turbidity (NTU)	15	13	18	13.2	1-5	High
Nitrate (mg/L)	23	42	35	18	45	Low
Phenols (mg/L)	0.035	0.1	0.091	0.078	0.001 – 0.002	High
Fluoride (mg/L)	1.28	1.63	1.26	1.22	0.6 – 1.2	High
Mineral Oil (ppm)	0.3	0.23	0.19	0.12	0.01	High
Hardness (mg/L)	721	1001	956	873	200 – 600	High
Sulphates (mg/L)	560	601	533	594	150 – 400	High
Calcium (mg/L)	246	385	402	279	75 – 200	High

them are at risk of contamination (Mason et al., 1999; Mikkelsen et al., 1997; Pitt et al., 1999).

According to the comparison chart shown in Figure 8, groundwater samples and river water samples have nearly equal qualities. The local soil composition may contribute to characteristics like nitrate, fluoride, and sulphate. The majority of the features, including calcium, hardness, mineral oil, and phenol, in both samples, are beyond the allowed thresholds, nevertheless. These characteristics are not brought about by the soil's inherent composition. These features are influenced by external influences, such as the manufacturing and processing industries present in the study region. The main factor for groundwater contamination is effluents generated from surface sources.

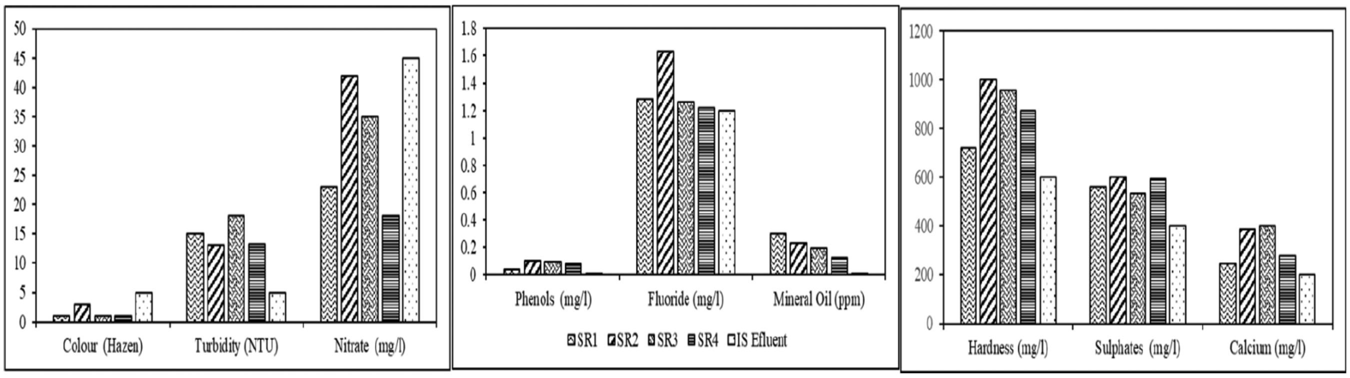

Figure 7: Properties of river water samples collected from the study area.

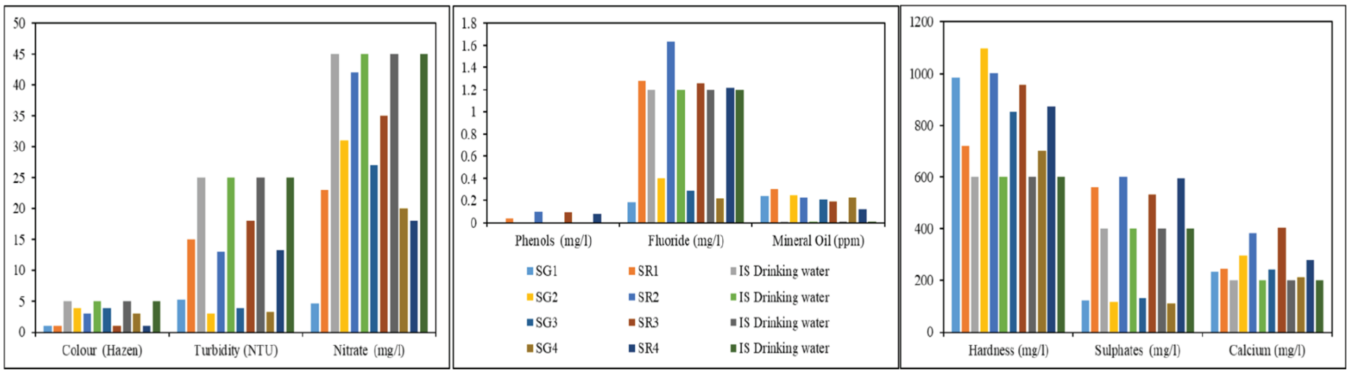

Figure 8: Comparison properties of ground water samples and river water samples collected from the study area.

Conclusions

This initiative aims to show that the groundwater in the selected study region is unfit for human consumption. If not, advice on possible treatments that could be employed to change them so they are fit for drinking. Most of the industries in the study region discharge treated wastewater into neighboring surface sources. Hence, contamination may result from surfaces contaminating groundwater. A thorough investigation is carried out to identify the problems with the groundwater. Water samples were taken, and they were examined in a lab to determine the amount of physical and chemical components that the groundwater contained. Standards for effluent and drinking water are compared to the results. The conclusions are,

- The sample water is found to have highly charged particles, rendering it unfit for construction, irrigation, or drinking.
- Certain water qualities, such as phenol, mineral oils, hardness, and calcium of the sample waters are higher than those in ordinary water, which causes skin cancer, colon cancer, and other diseases when consumed or utilised.
- Aeration and sedimentation are two preliminary methods that can be used to remedy some changes in water characteristics, it is found after comparing the data.
- Water properties are in a desirable range and are declared suitable for drinking after the treatment process is complete.

Author Contribution

Kalpana Manoharan conceptualised, developed, conducted, analysed, and produced the article. Padma Srinivasaperumal researched the literature and wrote the manuscript. The final manuscript was reviewed and approved by all writers.

Data Availability

The datasets used and/or analysed during the current investigation are accessible upon reasonable request from the corresponding author.

References

Adhikary, P.P., Chandrasekharan, H., Chakraborty, D. and K. Kamble (2010). Assessment of groundwater pollution in West Delhi, India using geostatistical approach. *Environmental Monitoring and Assessment*, **167(1):** 599-615.

Al-Sudani, H.I.Z. (2019). A review on groundwater pollution. *International Journal of Recent Engineering Science*, **6(5):** 14-22.

Ali, S., Fakhri, Y., Golbini, M., Thakur, S.K., Alinejad, A., Parseh, I. and P. Bhattacharya (2019). Concentration of fluoride in groundwater of India: A systematic review, meta-analysis and risk assessment. *Groundwater for Sustainable Development*, **9:** 100224.

Armienta, M.A. and N. Segovia (2008). Arsenic and fluoride in the groundwater of Mexico. *Environmental Geochemistry and Health***, 30(4):** 345-353.

Bhadra, B.K., Pathak, S. and J.R. Sharma (2013). Impact of industrial effluents on groundwater around Pali City, Rajasthan using field and satellite data. *Journal of the Geological Society of India*, **82(6):** 675-691.

Da'ana, D.A., Zouari, N., Ashfaq, M.Y., Abu-Dieyeh, M., Khraisheh, M., Hijji, Y.M., and M.A. Al-Ghouti (2021). Removal of toxic elements and microbial contaminants from groundwater using low-cost treatment options. *Current Pollution Reports*, **7(3):** 300-324.

David Noel, S. and M.R. Rajan (2015). Phytotoxic effect of dyeing industry effluent on seed germination and early growth of lady's finger. *J. Pollut. Eff. Contr*, **2(126):** 10-4172.

van Dijk, G., Wolters, J., Fritz, C., de Mars, H., van Duinen, G.J., Ettwig, K.F., et al. (2019). Effects of groundwater nitrate and sulphate enrichment on groundwater-fed mires: A case study. *Water, Air, & Soil Pollution*, **230(6):** 1-18.

Gowd, S.S. and P.K. Govil (2008). Distribution of heavy metals in surface water of Ranipet industrial area in Tamil Nadu, India. *Environmental monitoring and assessment*, **136(1):** 197-207.

Hui, T., Jizhong, D., Qifa, S., Yan, G., Zhuang, K. and J. Hongtao (2021). Evaluation of shallow groundwater for drinking purpose based on water quality index and synthetic pollution index in Changchun New District, China. *Environmental Forensics*, **22(1-2):** 189-204.

Imran, M., Crowley, D.E., Khalid, A., Hussain, S., Mumtaz, M.W. and M. Arshad (2015). Microbial biotechnology for decolorization of textile wastewaters. *Reviews in Environmental Science and Bio/Technology*, **14(1):** 73-92.

Johnson, S.L., Adams, R.M. and G.M. Perry (1991). The on-farm costs of reducing groundwater pollution. *American Journal of Agricultural Economics*, **73(4):** 1063-1073.

Khandegar, V. and A.K. Saroha (2013). Electrocoagulation for the treatment of textile industry effluent–A review. *Journal of environmental management*, **128:** 949-963.

Lee, J.Y., Moon, S.H. and S.T. Yun (2010). Contamination of groundwater by arsenic and other constituents in an industrial complex. *Environmental Earth Sciences*, **60(1):** 65-79.

Li, P., Karunanidhi, D., Subramani, T. and K. Srinivasamoorthy (2021). Sources and consequences of groundwater contamination. *Archives of Environmental Contamination and Toxicology*, **80(1):** 1-10.

Mason, Y., Ammann, A.A., Ulrich, A. and L. Sigg (1999). Behavior of heavy metals, nutrients, and major components during roof runoff infiltration. *Environmental Science & Technology*, **33(10):** 1588-1597.

Mikkelsen, P.S., Häfliger, M., Ochs, M., Jacobsen, P., Tjell, J.C. and M. Boller (1997). Pollution of soil and groundwater from infiltration of highly contaminated stormwater–A case study. *Water Science and Technology*, **36(8-9):** 325-330.

Nizam, S., Virk, H.S. and I.S. Sen (2022). High levels of fluoride in groundwater from Northern parts of Indo-Gangetic plains reveals detrimental fluorosis health risks. *Environmental Advances*, **8:** 100200.

Ozturk, E., Karaboyacı, M., Yetis, U., Yigit, N.O. and M. Kitis (2015). Evaluation of integrated pollution prevention control in a textile fiber production and dyeing mill. *Journal of Cleaner Production*, **88:** 116-124.

Pitt, R., Clark, S. and R. Field (1999). Groundwater contamination potential from stormwater infiltration practices. *Urban Water*, **1(3):** 217-236.

Ranjan, R.K., Ramanathan, AL., Parthasarathy, P. and A. Kumar (2013). Hydrochemical characteristics of groundwater in the plains of Phalgu River in Gaya, Bihar, India. *Arabian Journal of Geosciences*, **6(9):** 3257-3267.

Sajedi-Hosseini, F., Malekian, A., Choubin, B., Rahmati, O., Cipullo, S., Coulon, F. and B. Pradhan (2018). A novel machine learning-based approach for the risk assessment of nitrate groundwater contamination. *Science of the Total Environment*, **644:** 954-962.

Sharma, M.K. and M. Kumar (2020). Sulphate contamination in groundwater and its remediation: An overview. *Environmental Monitoring and Assessment*, **192(2):** 1-10.

Simonović, B.R., Aranđelović, D., Jovanović, M., Kovačević, B., Pezo, L. and A. Jovanović (2009). Removal of mineral oil and wastewater pollutants using hard coal. *Chemical Industry and Chemical Engineering Quarterly/CICEQ*, **15(2):** 57-62.

Stefanakis, A.I., Zouzias, D. and A. Marsellos (2017). Groundwater pollution: Human and natural sources and risks. *In:* Environmental Science and Engineering: Water Pollution Edition: 1st, Studium Press, **4:** 82-102.

Van der Bruggen, B., Everaert, K., Wilms, D. and C. Vandecasteele (2001). Application of nanofiltration for removal of pesticides, nitrate and hardness from ground water: Rejection properties and economic evaluation. *Journal of Membrane Science*, **193(2):** 239-248.

Venkatesan, G. and T. Subramani (2018). Environmental degradation due to the industrial wastewater discharge in

Vellore District, Tamil Nadu, India. *Indian Journal of Geo Marine Sciences*, **47(11):** 2255-2259.

Venkatesan, G. and T. Subramani (2016). Case study on environmental impact due to industrial waste water in Vellore district, Tamil Nadu, India using geospatial techniques. *Middle-East J. Sci. Res*, **24:** 152-159.

Verma, R.P., Mandal, R., Chaulya, S.K., Singh, P.K., Singh, A.K. and G.M. Prasad (2014). Contamination of groundwater due to underground coal gasification. *International Journal of Water Resources and Environmental Engineering*, **6(12):** 303-311.

Zheng, L., Wang, X. and X. Wang (2015). Reuse of reverse osmosis concentrate in textile and dyeing industry by combined process of persulfate oxidation and lime-soda softening. *Journal of Cleaner Production*, **108:** 525-533.

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