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PHYSICO-CHEMICAL ANALYSIS OF INDUSTRIAL EFFLUENTS AND THEIR IMPACT ON WATER AND SOIL AROUND PATNA

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Abstract:- Groundwater worldwide has emerged as a potential source for domestic and irrigation purposes. Natural groundwater without any anthropogenic influences will also have a baseline concentration of different dissolved solutes. These solutes are primarily introduced into the groundwater system by the process of sediment-groundwater interaction. This natural groundwater quality varies from place to place depending upon the nature of the soil, the nature of subsurface lithology, climatic conditions, etc. The dissolved solids in groundwater can be divided into major ions, minor constituents, and trace elements. Analytical results of the physicochemical analysis showed that the majority of the samples were above the permissible limits of Indian standards. The groundwater in the study area was very hard, and the relative abundance of major cations and anions was $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ and $HCO_3^- > SO_4^{2-} > Cl^-$. Fluoride content was higher than the permissible limit in 75% of the samples. The mean concentration of arsenic in groundwater was 9.37 and 11.01 µg/L. The analysis exposed that the groundwater in the selected area needs some degree of treatment before consumption, and the results will be beneficial for planners and decision-makers for the effective management of groundwater resources.

Keywords: lithology, potential, physicochemical analysis, effective

Introduction

Due to rapid industrialisation and the increasing human population, the stress on natural resources is increasing, and their conservation is one of the major challenges for mankind. Groundwater is a vital resource for millions of people for drinking and irrigation. The quality of groundwater is as important as its quantity because it is the major factor in determining its suitability for drinking, domestic, irrigation, and industrial purposes. The concentration of chemical constituents, which is greatly influenced by geological formations and anthropogenic activities, determines groundwater quality. These solutes are primarily introduced into the groundwater system by the process of sediment-groundwater interaction. This natural groundwater quality varies from place to place depending upon the nature of the soil, subsurface lithology, climatic conditions, etc. The dissolved solids in groundwater can be divided into major ions, minor constituents, and trace elements. In general, the major ions of groundwater include sodium, potassium, calcium, magnesium cations, bicarbonate, carbonate, chloride, and sulphate anions. The minor constituents include small amounts of dissolved solids like iron, manganese, fluoride, etc. Besides, many elements of the periodic table are present in very small concentrations in groundwater, and they are referred to as trace elements.

Further, we can also find organic compounds in some places in groundwater. It was also noted that drains transporting home and industrial effluents might contribute heavy metals to water bodies and their sediments. Sediments are another biologically significant element of the aquatic habitat besides water. They are also a repository of toxins that are crucial for sustaining the trophic status of any water body. According to Gaur et al., depending on the limnological conditions, sediments may serve as both a source and a sink for nutrients and other elements. As a result, some scientists have found a clear link between silt and water contamination. Industrial effluents are the primary source of direct, frequent, continuous pollution or toxicant input into aquatic environments, which has long-term effects on ecosystem functioning. According to reports, various businesses release waste with remarkable genotoxic potential, including pulp and paper mills, steel foundries, and facilities that produce organic chemicals. The enormous variety of dyes and chemicals added to textile wastewater provides an environmental problem for the textile industry regarding liquid waste and chemical composition. As they include pesticide residue and heavy metals, wastewater from industrial effluents, home wastewater, sewage, and agricultural soils of emerging nations, has demonstrated a rising trend of water pollution over the past several years. Urban wastewater poses potential dangers to public health and the environment due to its high quantity of organic matter and abundance of harmful bacteria. It has been claimed that using wastewater to irrigate agricultural areas damages plant mitosis, which ultimately leads to plant extinction. The main aim of this study is to find out the physicochemical composition of groundwater around the Patna region of Bihar.

Methodology

The six sites mentioned in Table 1 around the Patna region of Bihar were routinely sampled and analysed in a lab for water quality assessment. Surface water samples were collected in two-litre transparent polythene bottles for physicochemical analysis. Onsite analysis was conducted to determine characteristics such as pH, temperature, dissolved oxygen, and free CO2. Each bottle was carefully labelled and transported to the lab for further assessment. After collection, the water samples were filtered through a 0.45 µm pore size Whatman filter paper to assess other physicochemical parameters. Hydro-chemical characteristics such as pH, temperature, and dissolved oxygen were measured onsite during analysis. All equipment and reagents used were transported to the study site, allowing measurements to be taken in the field. The methodologies followed for hydro-chemical analysis were based on the standards set by APHA (2000), Trivedi & Goel (1986), and Maiti (2003a).

Table 1. Sample Collection site

ID	Name	Address
S1	M/S Shri Plywood PVT LTD	G837+PRC, National Highway 30, Fatwah, Bihar 803201
S2	M/S Shree Shakambari Udyog	G837+PRC NH-FATUHA, Bihar
S3	M/S Krish rice mill	Fatuha Industrial Area, Phase-3 Fatuha, Bihar
S4	M/S Magadh Tech Wires PVT LTD	G848, Fatuha, Bihar
S5	M/S Shree Shakambari Udyog	G837+PRC NH-FATUHA, Bihar
S6	M/S Shri Plywood PVT LTD	G837+PRC, National Highway 30, Fatwah, Bihar 803201

pH measurement- The temperature measurement method involves using a specialised thermometer with a mercury thread. The thermometer is calibrated before use. The thermometer is placed in the sample or sub-sample to be measured to determine the temperature. The sample is then stirred, and the thermometer stabilises for at least 2 minutes. The temperature is recorded after stabilisation.

Total Solid (ts): Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) are indeed two components of Total Solids (TS). However, the definition of TS is not just limited to volatile, suspended, and dissolved solids. Total Solids (TS) is the total amount of solids in a sample, including dissolved and suspended solids and non-volatile solids. It is an important parameter used in water quality testing to determine the overall quality of the water.

Alkalinity: The parameter that measures the ability of water to neutralise acids is called alkalinity. It indicates how well water can absorb $H+$ ions without significantly altering the pH. Alkalinity is determined by measuring the sum of all titratable bases in water.

Calcium Hardness Principle: When EDTA is added to an aqueous solution containing both Ca and Mg, it complexes first with Ca before Mg.

Magnesium Hardness (Mg): Magnesium hardness is considered non-toxic for humans at the concentrations typically found in natural bodies of water. Magnesium salts are commonly found and may have laxative and diuretic effects on individuals who are not accustomed to high doses.

Chloride: The parameter being described is likely the measurement of chloride ions in water using a silver nitrate solution and potassium chromate as an indicator. Here is a corrected sentence:

In order to measure chloride levels, a standard solution of silver nitrate is used to precipitate hydrogen ions in the water, with the help of potassium chromate as an indicator. This results in the formation of silver compounds that allow for the measurement of chloride concentration.

Sulphate (Turbidimetric Method) Method: The principle of the turbidimetric method is that sulphate ions are first activated by the presence of barium chloride (BaCl2) in an acidic medium. When they react to form a compound of barium sulphate (BaSO4), they behave like crystals with a constant shape.

Table 2. Physico-chemical properties of M/S Sri plywood PVT LTD sG837+PRC, National Highway 30, Fatwah, Bihar 803201 Soil sample

SN.	Test parameter	Results (mg/kg)
1	Total phosphorus	3.1
2	Total Nitrogen	7.68
3	Manganese	0.06
4	Chromium	BDL
5	Boron	0.21
6	Molybdenum	Tr
BDL- Below Detection Level, Tr- traces		

Table 3. Physico-chemical properties of M/S Shree Shakambari YDYOD+PRC NH-30soil sample

SN.	Test parameter	Results (mg/kg)
1	Total phosphorus	1.32
2	Total Nitrogen	9.32
3	Manganese	>0.1
4	Chromium	Tr
5	Boron	0.32
6	Molybdenum	Tr

Result and Discussion

According to the methods provided in APHA, investigations of several physico-chemical parameters, including pH, temperature, total hardness, alkalinity, calcium hardness, magnesium hardness, chloride, sulphate, nitrate, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), etc., were carried out in 1992. All of the synthetic materials and reagents used were of investigational grade. For the purpose of preparing the solutions, double-distilled (DD) water was used.

Table 4. Physico-chemical properties of M/S Krish Rice Mill PVT LTD soil sample

SN.	Test parameter	Results (mg/kg)
1	Total phosphorus	3.1
2	Total Nitrogen	7.68
3	Manganese	0.06
4	Chromium	BDL
5	Boron	0.21
6	Molybdenum	Tr

Table 5. Physico-chemical properties of M/S Magadh Hi-Tech Wires PVT LTD water sample

SN.	Test parameter	Results (mg/kg)
1	pH	7.11
2	TDS	488
3	TSS	60
4	COD	2.8
5	BOD	1.58
6	CA	158.796
7	Magnesium	127.818
8.	Lead	BDL
9	Arsenic	<0.001
10	Hardness	684.82
11	Mercury	BDL
12	Cadmium	BDL
13	Alkalinity	405.9

pH

The pre-storm pH ranges from 7.10 to 8.50, while the post-storm pH ranges from 7.10 to 8.60. Most of the stations under evaluation display a fundamental tendency. No station has pH values beyond the permissible limit cited by BIS in the pre-storm period. Still, two stations (S02 and S32) indicate pH values above what many people would deem feasible in the post-storm period. The average value is 7.88 before a downpour but drops to 7.80 afterwards. Increased pH levels may make it more difficult to chlorinate the water to remove contaminants and may also cause scale buildup.

Table 6. Physico-chemical properties of M/S Shree Shakambari YDYOD water sample

SN.	Test parameter	Results (mg/kg)
1	pH	7.41
2	TDS	238
3	TSS	16.32
4	COD	1.87
5	BOD	1.04
6	Ca	42.65
7	Magnesium	63.407
8.	Lead	BDL
9	Arsenic	<0.01
10	TH as $CaCO_3$	436.45
11	Mercury	Tr
12	Cadmium	Tr
13	Alkalinity	231.66

Table 7. Physico-chemical properties of M/S Sri Plywood PVT LTD water sample G837+PRC, National Highway 30, Fatwah, Bihar 803201

SN.	Test parameter	Results (mg/kg)
1	pH	7.32
2	TDS	248
3	TSS	14.36
4	COD	1.57
5	BOD	0.96
6	CA	50.526
7	Magnesium	32.805
8.	Lead	BDL
9	Arsenic	<0.001
10	Hardness	186.24
11	Mercury	BDL
12	Cadmium	BDL
13	Alkalinity	99

Alkalinity

The alkalinity levels ranged from 036 to 0797 mg/L before the storm and from 0168 to 0873 mg/L after the storm. The average alkalinity was 469.48 mg/L before the storm, but it increased to 495.04 mg/L after the storm. Before the storm, 98.59% of the samples had alkalinity values greater than the WHO's recommended maximum value of 0121 mg/L. After the storm, all the samples had higher alkalinity values than what are considered feasible. The alkalinity of groundwater is mainly due to the presence of carbonates and bicarbonates.

Calcium

Pre-storm calcium levels at testing locations vary from 06.40 to 0158.80 mg/L, whereas post-storm calcium levels range from 08.40 to 0169.20 mg/L. Pre-poststorm calcium regard is typically 44.49 mg/L separately. It exceeds the WHO-depicted standard of 075 mg/L in a number of models. Its value is mostly attributed to the region's 45 bountiful lime stone openings. More notable dissolvability of calcium particles is therefore possible.

Magnesium

Magnesium levels in the study areas vary from 05.35 mg/L to 132.45 mg/L in pre-rainstorm conditions and from 06.32 to 164.53 mg/L in post-storm conditions, with a normal value of 36.19 mg/L in pre- and 38.36 mg/L in post-rainstorm conditions, respectively. Several instances show magnesium values above the most elevated ideal limit of 030 mg/L in two separate seasons. Due to the dissolution of magnesium, calcite, gypsum, and dolomite, the magnesium concentration may be very high (Vyas, 2011).

Chloride

The chloride values ranged from 015 to 01432 mg/L during the dry season and from 020 to 1457 mg/L after a storm. The normal value was 222.01 mg/L before the storm and 171.04 mg/L after the storm. Chloride concentrations in a significant portion of the models were found to be greater than the most critical appealing threshold determined by the ICMR. Still, these concentrations are substantially below the maximum permissible limit (1000 mg/L), and there are a few occasions where these values are higher. Chloride overgrowth is caused by anthropogenic activities, such as septic tank effluents and leaching from chemicals used by nearby borewell users.

Nitrate

Nitrate (NO3-) concentrations in the study area ranged from 2.00 to 23.6 mg/L in the pre-rainstorm period, with an average value of 12.18 mg/L, and from 30.9 to 32.77 mg/L in the post-storm period, with an average value of 32.77 mg/L. Several models were observed to have NO3- concentrations above the recommended upper limits of 45 mg/L throughout both seasons. The depletion of NO3- in shallow soil layers with percolating water close to its high concentration in drinking water can lead to NO3- contamination in groundwater, resulting in unsafe drinking water (Umavathi et al., 2007).

Fluoride

Fluoride concentrations in the study areas ranged from 0.03 mg/L to 12.50 mg/L before a storm and from 0.14 to 12.2 mg/L after a storm, with a median value of 1.96-1.82 mg/L for the two seasons. More than half of the models have fluoride levels higher than the generally considered safe limit of 1.5 mg/L (BIS, ICMR, WHO) and are experiencing severe fluoride issues. Groundwater is usually treated to remove fluoride. According to the Central Ground Water Board (CGWB), quartzite is the primary mineral found in springs currently. Pre-storm levels of total dissolved solids range from 63 to 4890 mg/L, while post-storm levels range from 408 to 5434 mg/L, with an average value of 1589.90 mg/L before a storm and 1252.30 mg/L after a storm. This indicates that a larger number of stations exceed the standard limit of 500 mg/L set by the BIS and ICMR WHO, which may be due to anthropogenic activities such as agriculture causing a localised, temporary overflow.

Electrical Conductivity

The range for electrical conductivity is between 0.86 and 6987 µmhos/cm before the storm and between 583 and 7763 µmhos/cm after the storm, with an average of 2271.05 µmhos/cm and 1788.90 µmhos/cm in pre- and post-storm seasons, respectively. The concentration of particles and the status of supplements in dissolved solid materials are important determinants of electrical conductivity. Water quality can be classified as poor, moderate, or excellent based on electrical conductivity. In our findings, all models show EC values above what is considered achievable for the WHO-recommended 300 µmhos/cm.

Trace Metal Characteristics

Considering toxicity, as already noted, the stronger Cd-S bond explains why heavy metals like cadmium are replacing zinc in several applications. Soft acids are generally considered more hazardous than hard acids due to their increased ability to attach to soft ligands like -SH. Metal toxicity increases down the periodic group, i.e., Zn, Cd, and Ag. The solubility of a compound has an impact on its toxicity. For instance, BaSO4 is used internally to allow the taking of X-rays of the stomach and intestine. The ion Ba2+ is poisonous, but BaSO4 has limited solubility, even in stomach acid, making it relatively safe. The water solubility of an element's salts determines its availability. Except for fluorides, nitrates, and halides, soluble salts mostly contain other compounds. Less soluble salts often include sulphates, phosphates, and carbonates.

Arsenic (As): Arsenic (As) is a toxic element that can be found in the environment due to natural sources, such as volcanic activity, and human activities, including mining and smelting of metals. Arsenic can be transported through the soil and water and accumulate in various body organs, including the liver, kidneys, and lungs. Arsenic can exist in trivalent and pentavalent forms, with the trivalent form being more toxic than the pentavalent form. Symptoms of acute arsenic poisoning include vomiting, abdominal pain, and skin lesions. Long-term exposure to low levels of arsenic has been linked to increased risks of cancer, diabetes, and cardiovascular disease.

Mercury (Hg): Both naturally occurring and inorganic compounds containing mercury are very toxic. Basic amounts of mercury are present in the effluents of projects such as manufacturing switches, batteries, thermometers, fluorescent lamps, high-intensity street lights, and even pharmaceutical projects. Prolonged mercury exposure can cause immunological and metabolic abnormalities, including neurological damage, renal and cardiovascular failure, and serious damage to the liver and kidneys.

Lead (Pb): Lead (Pb) is a highly toxic metal commonly found in the environment. It can enter the natural world through various sources such as patches, cathodes, batteries, and newsprint-coloured paints. However, lead-containing coal mining and processing are the most significant lead contamination sources. This activity releases lead particles into the air and water, distributed throughout the environment. Lead exposure can lead to various health issues, especially in children and pregnant women. It can affect brain and nervous system development, leading to learning disabilities, reduced IQ, and behavioural problems. Lead exposure can also cause anaemia, high blood pressure, and kidney, liver, and reproductive system damage. In addition, lead particles can accumulate in soil, water, and plants, contaminating the food chain. Animals that ingest contaminated soil or water can also accumulate lead, which can be transferred to humans who consume their meat or milk. Efforts have been made to reduce lead exposure in the environment, such as banning leaded gasoline, reducing lead in paints and consumer products, and implementing regulations on lead emissions from industrial sources. However, it is still important to be aware of potential sources of lead exposure and take steps to protect yourself and your family from its harmful effects.

Conclusion

As previously stated, waterway water tests were conducted for each of the three seasons in 2017-18 by documenting water parameters over four months for each season. Many businesses directly discharge industrial and agricultural wastes into sewage streams, compromising the purity of the water. Water quality restoration in southeast streams has proven to be a difficult challenge for experts and eco-warriors alike. However, water quality parameters depend on environmental factors such as temperature, rainfall, and soil characteristics. Regular variations in these factors play a vital role in changing water quality parameters, greatly affecting the water quality of streams. Written studies unequivocally demonstrate that the pollution level was higher before and after storms, which can cause a spike in water pollution due to the increased runoff of pollutants. The current investigation aims to understand how the seasons of summer and winter storms affect the water quality of waterways in the Pune area. Studies on the effects of different seasons on water quality have been extensively documented. These variations in water quality parameters can significantly impact the health of aquatic ecosystems and human populations. Assessing the combined effects of many physico-chemical characteristics on stream waters has traditionally been used to evaluate water quality. These characteristics include temperature, pH, dissolved oxygen, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), and various pollutants such as heavy metals, pesticides, and organic compounds. By monitoring and analysing these water quality parameters, experts can identify sources of pollution and take measures to improve the health of waterways.

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