

GROUND WATER QUALITY OF INDO GANGETIC PLAIN REGION: A REVIEW**Simranjeet Singh**simranjeet_fps@sgtuniversity.org
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Abstract

In many nations where rivers and drainage systems are insufficient, groundwater has replaced them as the primary source of water used in agriculture. As a result, in recent years, low groundwater quality for irrigation purposes has raised concerns. Groundwater pollution is a result of inadequate or excessive use of chemical fertilizers. The quality of groundwater is influenced by the type of recharging water, precipitation, subsurface and surface water, hydro-geochemical processes in aquifers, changes in land use and land cover, and mining activities. Periodic changes in groundwater quality are usually caused by temporal changes in the makeup and source of the water recharged, as well as by human activity. Groundwater quality deteriorates in two ways: first, as a result of geochemical reactions in the soils and aquifers, and second, when it is provided for irrigation through inefficient canals or drainages. Therefore, it is essential to regularly evaluate the quality of drinking and irrigation water. A sufficient amount of usable water must be available for irrigation. Irrigation demands sufficient water supply of usable quality. It may be helpful to use an index based on the composition and concentration of dissolved components in water to assess whether it is suitable for agricultural use. The type of mineral components present in the water and how they affect the soil and plants determine whether or not groundwater is suitable for irrigation. This paper reviewed groundwater hydro chemistry of the Indo Gangetic Plain region in relation with irrigation and overexploitation of groundwater. Also considering the changes in the physico-chemistry of the aquifers of the region, with respect to monsoon. It was observed that in most of the IGP regions water quality becomes unfit for irrigation purpose during post-monsoon due to leaching of pollutants. High concentration of various salts and heavy metals in the groundwater was also found due to the high siltation, erosion and leaching activities.

Key words: Indo Gangetic Plain, pollution, irrigation, aquifers, hydro chemistry.

Introduction:

Water is one of the most exploited natural resource. It is used in every sphere of human activities. The demand for water is increasing with increase in population, expansion of irrigation, continued urbanization and industrialization. However, the water resources are likely to remain constant.

Ground water constitutes about 0.6% of total water available on our planet. But 50% of this is practically not available for human consumption as it is present at depth more than 1000 meter ground water is the only source of water for about 50% of our countryman. Groundwater forms a major source of drinking water supply for urban and rural people of India. It is preferred over surface water due to non-availability of other water sources and the consideration that surface soil-strata acts as a natural filter providing safe and pure water.

Groundwater is one of the crucial natural sources for irrigation, drinking and other domestic purposes. In India around 68% population is dependent on groundwater for their daily activities, the increasing population has contributed to the over-exploitation of several aquifers hindering their sustainability. This over-exploitation has lead to a compromise in the groundwater quality, with 33% of India's aquifer, not safe for drinking purpose. To sustain a growing economy like India, higher production is required with increased water requirements hence, the groundwater in India is majorly utilised for irrigation purposes, which has resulted in overexploitation of this natural resource. Over irrigation has adversely affected the aquifer's hydro chemistry with increased phenomenon of salinity and alkalinity. This has also resulted in a decline of water table in most parts the country as the discharge rates are much higher than the replenishment or recharge rates.

This study is a situation analysis of groundwater hydro chemistry of the Indo Gangetic Plain region including Punjab, Haryana, Uttar Pradesh, Bihar and Jharkhand in relation with irrigation and overexploitation of groundwater. Also considering the changes in the physico-chemistry of the aquifers of the region, with respect to monsoon.

The Indo Gangetic Plains have also contributed to an increased concentration of various salts and heavy metals in the groundwater due to the high siltation, erosion and leaching activities in the region. One classic example could be the increased levels of arsenic in groundwater of Bihar due to the presence of high content of silt in this region, which is a pioneer requirement for Arsenic adsorption and its leaching.

Indian economy majorly depend on agriculture, more than 80% of India's water resources are used for irrigation, with groundwater being one of the country's main sources. Due to this much heavy dependence on groundwater our water table levels are going down and on top of that they are being contaminated by transport of fertilizers and pesticides to them. The level of contamination generally depends on the adsorptive capacity of soil and its permeability. (Ravish S., et al, 2018).

The salinity levels of groundwater differs from region to region and majorly depends on the climatic conditions mainly rainfall and the chemical composition of parent rock. The variability of groundwater quality depends on the spatial, temporal and vertical variations. On the basis of groundwater surveys of different hydrological zones, soils and agro climatic zones of the country it has been concluded that the groundwater quality of arid and semi-arid regions fall under marginal to poor class while quality from water in the Eastern regions with heavy rainfall come under good category. Quality of ground water in coastal areas comes under poor quality because of the intrusion

of seawater. And due to various anthropogenic activities the groundwater is further contaminated with heavy metals and E coli.

Natural and Anthropogenic Sources:

Groundwater is polluted by natural as well as anthropogenic sources. Natural pollutants include acid rain and salts from the rocks etc., whereas, other hazardous pollutants are added by anthropogenic activities including domestic wastes, agricultural wastes, soluble effluents, industrial wastes etc. via seepage and leaching.

In the Indo Gangetic plains (IGP region) of India natural as well as anthropogenic activities has affected the groundwater quality in the region making it unfit for agricultural as well as domestic use. The levels of Total Dissolved Solids (1075 mg/L), Total hardness (463.9 mg/L), alkalinity (443.9 mg/L), Chlorine (230.5 mg/L), Sulphate (125.8 mg/L), sodium (320.7 mg/L) are higher than the permissible limits. High levels of certain metals like Cr (0.0024 mg/L), Fe (0.171 mg/L), Mn (0.11 mg/L), Zn (0.225 mg/L) were also detected indicating heavy metal toxicity. The groundwater was of Mg-Na-HCO₃ type and high levels of Na increased the salinity in groundwater of that region along with high concentration of alkalinity content renders it unsuitable for irrigation (Singh K. P. et al, 2005). Irrespective of this, the Dhanbad region of IGP, Jharkhand has varying quality of ground water. The analysis of 79 wells indicates the suitability of groundwater for drinking purposes despite the presence of many heavy industries and coal mines. Except for few samples that exceed the permitted limits of Total Hardness (500 mg/L) with low alkalinity and a slight risk of salinity with Ca⁺ and Mg⁺ ions as dominant cations and HCO₃⁻ and SO₃⁻ ions as the dominant anions, the groundwater is suitable for industrial usage as well as irrigation. (Chatterjee R. et al, 2010).

Heavy metals are toxic metals generated through industrial processes like battery manufacturing, pesticides, alloys, textile dyes, electroplated metal parts, steels etc. Two thirds of the 35 metals that potentially pose risks due to exposure in the home or at work are heavy metals. These heavy metals are hazardous as they tend to accumulate and lead to heavy metal poisoning through contaminated groundwater as they leach through soil marking the application of excess fertilizers and pesticides as one of the major contributors. (Ravish S., et al, 2018).

Table.1 Permissible limits of heavy metals

HEAVY METAL	PERMISSIBLE LIMIT
Arsenic	2.6-9.2ug/l
Cadmium	0-0.61ug/l
Cobalt	4.3-17.8ug/l
Copper	7.5-28.4ug/l

Lead	0.96-5.84ug/l
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The pH of water depends on relative concentration of ions- calcium, carbonate and bicarbonate ions. The pH of irritated water becomes acidic due to mixing of nitrate from fertilizers with it to form nitric acid which lead to the corrosion of pipes with the release of toxic heavy metals (Cu, Cd, Zn, and Pb) into the groundwater, while alkaline pH leads to formation of toxic chemical, Trihalomethane, which can lead to serious health issues. The ground water samples from Anekal Taluk, Bangalore were found with alkalinity (275.68 mg/L), Cl⁻ (218.15 mg/L), Total hardness (225.59 mg/L), Fluoride (0-16 mg/l), NO₃⁻ (2.00 mg/L), SO₃⁻ (18.63 mg/L), Fe (1.26 mg/L) and e-coli (12/100 ml). It was found that 81% groundwater samples exceeded the BIS standards of Fe, F, and e-coli which results in health problems like Fluorosis, Hemochromatosis, Pneumonia respectively. Hence the water was unfit for domestic purpose and due to high alkalinity and total hardness it rendered the water unfit for irrigation purpose also (Prakash K. L. and Somashekhar R. K., 2006).

Water Quality during Pre-monsoon and Post-monsoon:

The physico-chemistry of groundwater not only depends on numerous factors like the type of crops grown, type of soil, climatic conditions of the region and management of irrigation practices in the region. Rainfall can also alter the physico-chemistry of groundwater both positively and negatively depending on the average annual rainfall of that region, an average of 300 millimetre can result into an increased alkalinity due to the leaching of the ions, by dissolution with rainwater, into the aquifer. Increased pH, Sodium Absorption Ratio and Electrical Conductivity levels are observed in groundwater during monsoon along with high levels of other parameters also, like chlorine, calcium, heavy metals, alkalinity, turbidity, and total dissolved solids. While arid seasons are marked with high levels of total hardness, magnesium, sodium, nitrate and salinity (Ravish S., et al, 2018).

The ground water quality changes greatly from pre-monsoon to post-monsoon season. In pre-monsoon the Na-Ca-HCO₃ water type was dominant while Mg-HCO₃ type was dominant during post-monsoon. Although monsoon fixes the alkalinity, RSC, SAR, and Salinity of the groundwater, still the samples collected from Karnal district fall under doubtful to unsuitable categories on the basis of salinity, RSC, and percent sodium levels for irrigation (Tomar V. et al, 2012).

The physico-chemical properties of ground water are greatly affected by rainfall. In arid and semi-arid regions ground water is the primary source of irrigation for sustainable crop production. Hence the changes in the quality of aquifers greatly affects the crop productivity in these regions, the analysis of pre-monsoon and post monsoon groundwater quality in the Ghana block of Haryana state indicates no significant improvements in the physico-chemistry with similar values of pH

(8.5), sulphate (2.56 mg/L), nitrate (2.56 mg/L), Potassium (0.57 mg/L). Although, sodium was found to be the dominant cation (33.2 mg/L) and Chlorine as the dominant anion (33.2 mg/L), which lead to an increase in the salinity levels. High levels of sodium further adds to the higher SAR and RSC levels with 13.6 mmol/L and 2.40 me/L respectively and lead to high sodicity of ground water (Pradhan S. et al, 2011).

Table.2 Sodium Hazard Classification.

CLASS	SAR	SODICITY CLASS
Class I	<3	No sodium problem
Class II	3-6	Low, few problem
Class III	6-8	Medium, many problem
Class IV	8-14	High, generally not recommended
Class V	>14	Very high, Disregard

When ground water quality and hydrochemistry in certain areas of Noida, Uttar Pradesh, were being studied, it was found that the groundwater was alkaline and saline with high levels of TDS, Total hardness, sodium, sulphate, chlorine, Iron and other metals beyond the permissible limits making it unsafe for ingestion but for irrigation purpose it was under good to permissible category, except some regions with high salinity which were recommended to grow salt tolerant crops (Singh A. K. et al ,2011).

The ground water assessment of Lutfullapur Nawada, Loni, showed that the region has high levels of alkalinity, Cl^- , Na^+ , K^+ and HCO_3^- which might be due to occurrence of redox reaction in mineral solution and heavy infiltration during monsoon. But concentration of metals like zinc, cadmium, lead, chromium, nickel and copper were under BIS permissible limits except concentration of Iron which exceeded upto 1000 mg/L in 33% of samples. The groundwater can be used for domestic purposes only after Iron remediation but based on the criteria of RSC majority of samples were considered safe for irrigation. It was also found that deep installations have better quality water than shallow installations (Singh V. K. et al, 2012).

Usually monsoon improves the quality of ground water by water percolation and dilution of impurities. But sometimes it may worsen the condition just like in the alluvial aquifers of Bathinda, South west of Punjab state. The groundwater hydro chemical nature was investigated by measuring the physico-chemical parameters along with major ion chemistry for drinking as well as irrigation

purposes. By comparing the water chemistry before and after monsoon showed contamination of majority of samples during pre-monsoon; Fluoride (72%), sulphate (28%), Total hardness (25%), Magnesium (22%), Nitrate (22%), Total dissolved solids (11%), and Bicarbonate (22%) as well as during post-monsoon, Fluoride (50%), sulphate (22%), total hardness (28%), magnesium (39%), nitrate (22%) and total dissolved solids (28%) above the permissible levels for drinking purpose. For irrigation suitability, parameters like SAR, RSC and % Sodium were analysed and showed that the majority of the water samples were within good to suitable categories during pre-monsoon, while during post monsoon comes under doubtful to unfit category. Na⁺ ion was found to be the dominant cation followed by Magnesium and Calcium while Cl⁻ ion was the dominant anion followed by HCO₃²⁻ and SO₄²⁻ ions.

Table.3 Comparison of Water quality parameters before and after Monsoon

PARAMETERS	PRE-MONSOON	POST-MONSOON
Fluorine	72%	50%
Sulphate	28%	22%
Total Hardness	25%	28%
Magnesium	22%	39%
Nitrate	22%	22%
Total Dissolved Solids	11%	28%

The geochemistry of groundwater was controlled by silicate and carbonate mineral dissolution and ion exchange during pre- monsoon while controlled by leaching of salts deposited in the soil layer by infiltration during the post-monsoon period (Sharma D.A., et al, 2016). Punjab is an agricultural state as 83% of its geographical area is used for cultivation with 80% of its population dependent on agriculture for their livelihood. Since surface water resources are limited in this state, agriculture is primarily dependent on ground water for irrigation, about 73% of cultivated land is irrigated using ground water which has led to drop in water table in some areas and rise in water table in some areas like South-western Punjab, creating waterlogging and salinity problems due to limited extraction of ground water as compared to other regions because of brackish/ alkaline quality. In order to get ground water fit for irrigation, deep installations are required. During investigation of 45-60m wells in the region it was found that the relative abundance of Na and excess of carbonate and bicarbonate concentration in groundwater make it highly suitable for irrigation. The groundwater had high Electrical conductivity and residual sodium carbonate (RSC) which lead to high pH and make the land, cultivated with this water, infertile. About 53% samples

were categorized fit, 22% as marginal and 25% as unfit for cultivation. To tackle such condition certain steps must be taken like increasing permeability, adequate drainage, excess irrigation to increase leaching and use of salt tolerant crops (Chopra R.P.S and Krishan G., 2014)

Consumption of polluted water or crops produced from polluted water can directly affect human health. Release of toxic and hazardous constituents in groundwater by industrial and agricultural processes has led to the contamination of drinking water. Contamination of drinking water with heavy metals like lead, arsenic, mercury, cadmium and chromium can cause severe diseases like water contaminated with arsenic can lead to renal failure, arsenic poisoning and can become a potent carcinogen on frequent exposure, causing cancer of bladder, skin, lungs and liver. On the other hand exposure to cadmium can lead to lung damage, kidney failure, fragile bones etc. Human kidneys and brain can be severely damaged by consumption of lead contaminated water while mercury can lead to congenital malformation, abortions and gastrointestinal disorders (Sankhla M. S., et al, 2016).

The suitability of ground water of Kaithal district, Haryana for irrigation purpose was found between moderate to doubtful range with pH (7.2-9.2), EC (0.47-6.06 ds/m), calcium (0.4-3.0 mg/L), magnesium (1.1-11.0 mg/L), sodium (3.2-53.1 mg/L), potassium (0.06-1.00 me/L), carbonate (1.43 mg/L), bicarbonate (4.66 mg/L), chlorine (7.32 mg/L), sulphate (7.20 mg/L) and nitrate (0.46 mg/L) and it was concluded that the groundwater was unfit for irrigation usage (Singh V.K. et al., 2018).

Alkalinity of the aquifers can be increased by the influx of bicarbonate ions in groundwater, due to reaction between CO₂ in the soil space and rainwater as found in Sant Ravidas Nagar, Uttar Pradesh. The region's 90% samples were Ca-Mg-HCO₃ water type with Calcium as the dominant cation and Bicarbonate as the dominant anion. Most of the samples fall under the desirable to permissible category and were safe for irrigation according to WHO standards. Although 40% samples had high concentration of Nitrate because of excess use of nitrogen fertilizers, animal excreta, domestic sewage and their leaching in groundwater aquifers. But certain measures can be taken to reduce the Nitrate concentration like Bioremediation, reverse osmosis, physical adsorption etc., before use (Sughosh M. et al, 2018)

During ground water assessment of Yamunanagar and Ambala district in north-eastern India, it was found that utilization of the groundwater will not cause any harm or threat to agriculture except the slight alkalinity in some areas due to mineral dissolution, excess irrigation and improper sewage disposals. Slight dominance of Na in ground water may lead to increase in salinity and higher Sodium percentage in future (Ravish S. et al, 2020).

Ground water for drinking as well as irrigation purposes was investigated in the southern region of Haryana state including Gurugram, Faridabad, Mahendragarh, Palwal and Rewari district to check the quality of The groundwater falls under the permissible category for irrigation but 85% samples were unsafe for drinking purpose. The SAR and RSC fall under excellent to safe class but percent Na exceed the limits leading to high salinity in 88% of water samples because of high evapotranspiration and excess use of agrochemicals (Kumari M., Rai S.C.,2020).

Conclusion:

Unplanned discard of sewage, industrial effluent, and industrial solid waste, and unwise utilization of chemicals in the form of pesticides, fertilizers, insecticides, etc., in agricultural activities, are the major contributing factors to the reduction of groundwater quality. The leaching of these chemicals/effluents is aggravated in the monsoon season. In some cases, the monsoon helps in the dilution of salts present in groundwater and improves its overall quality, in another case, it may deteriorate the quality by solubilizing all the salts present in the soil into the groundwater. This finding will be useful for policy makers to identify agricultural practices that improve well water quality in areas of intensive agriculture such in IGP region. However, a long-term research approach that incorporates the economic and environmental impacts of well water and associated agricultural practices would provide insights into the issue in a broader context.

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