CHAPTER 8

SUMMARY AND CONCLUSION
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Water the elixir of life is considered as most abundant element on the earth but the part of water, which is usable for the various purposes, is less in quantity. Every aspect of life and every daily use activity require some amount of water so the world can move without diesel and petrol but there is no possibility of life on the earth without water. It has always been a matter of concern from the older times as evidenced by great ancient poet Raheem

*Rahiman paani raakhiye bin paani sab soon,
Paani gaye na oobare moti, manus, choon.*

These lines also describe the necessity of water and its conservation. Agriculture can flourish in some deserts, but only with water either pumped from the ground or imported from other areas. Ryan(2004) has stated that in India the groundwater table is receding faster than it is in the rest of the world. The result is that we can get a cola or whisky easily but not a bottle of pure water.

However, the Rajashtan of which Jaipur is the capital is situated in the Thar deserts of the Indian subcontinent has always suffered from water crisis. Years of rapid population growth and increasing water consumption for agriculture, industry, municipalities, and other areas have strained the fresh water resources.
Until quite recently, rural populations depended on surface water from lakes, ponds, wells, and rivers that exposed them to a variety of water related diseases. The shift from surface to groundwater has undoubtedly reduced the risk of microbial contamination despite the fact that most water remains untreated. However, this shift has given rise to another set of problems. In some parts of the region, groundwater is contaminated with chemicals that are harmful to health.

In the present study related to the Jaipur Urban area under topic “Water status, quality development and augmentation of water resources in urban limits of Jaipur, Rajashtan” every aspect of ground water hydrology has been measured with intense care. The study involves groundwater level measurement through piezometers located in the area and measuring the water level fluctuation, occurrence of ground water, movement of ground water, ground water quality by measuring different chemical constituents dissolved in ground water, estimation of recharge and discharge and overall management options in regard to problems of over-exploitation and quality degradation step by step.

Water plays a decisive and crucial role in the growth and location of settlements, the demand for water has been rising in the urban centre not only due to accelerated growth in the economic activities and social heads. In the long run this rapacious exploitation is bound to end up in an ecological crisis if the required pre-equipitive measures are not taken.
The Jaipur area comprises almost flat plain land with clusters of sand dunes in the south-western part and a long rocky ridge extending roughly from north-north east to south-south west. The Jaipur urban area comprises no main river or canal within its agglomerates. It is drained by a Nalla from north to south, which meets to the Mendha River in the south at Sanganer block outside the urban limit, and this river is also ephemeral in nature and flows only in monsoon period.

To evaluate the geochemical properties of the groundwater representative water samples were collected from the entire area.

The criteria of water quality may be defined as the concentration quality, or intensive measure that if achieved or maintained, will allow or make possible a specific water use (Mc Cutcheon et al. 1992). According to Freeze et al. (1979) water is effective on deviating salts because it has a very high dielectric constant and because its molecule tend, to combine with ions to form hydrated ions. The quality of water changes from place to place and season to season depending upon the natural and human influences. It is necessary to monitor the quality of water in order to ascertain the suitability for certain uses which are present in the water samples affect the quality of water.

The successively increasing of chemical in rivers and other water bodies, resulting from the enhanced discharge of industrial and municipal wastewater has become the major problem affecting the water quality.
Various industrial plants located in the study area discharge significant untreated waste effluents into the river through drains and sewage pipes and also on the ground surface, which are in the immediate vicinity of the plants. Among these wastes, the significant pollutants like BOD, COD, DO, suspended solids, oils and greases together with a number of trace metals like Cu, Zn, Cr, Mn, Fe, Cd etc, subsequently leached down and pollute the surface water and associated soil sediments. Position, drainage pattern, soil type and chemistry, geology, population pattern, social status and other elements of environmentally compatible micro-level planning of the region has to be prepared before establishing any industrial complex which might help in alleviating the pollution and selecting the proper disposal sites.

As a result of pollution, there is an increasing need to treat water before it is suitable for diverse uses like drinking, irrigational purposes to treat wastewater before it is discharged back to the water cycle. This contamination of surface water bodies and soil mainly caused by presence of various types of industrial effluents as well as human impact i.e. the use of different types of detergents, solid waste materials. The quality of water, measures of chemical, physical and bacterial constituents are important, depending upon the purpose for which it is utilized.
The principal sources of water and soil pollution in the study area are municipal, industrial and agricultural waste and out of these, industrial wastes are the most troublesome to control. A survey of major elements and heavy metal concentrations in ground water of the study area has been of great importance because of their high toxicity and non-degradable nature and their potential to cause various adverse effects in human beings at certain level of exposure and adsorption.

The concentration of chloride in groundwater samples ranges in pre and post monsoon between 34.08ppm-477.12ppm and 25.56ppm-999.68ppm. In major parts of the area chloride content is below 200 mg/l. Higher contents of chloride in groundwater (999.68ppm in sample no. 1) and lowest content (25.56ppm in sample no. 21) were observed in Jalmahal area in the NE and Vidhyadhar Nagar in the NW Jaipur. A high concentration of chloride gives salty taste to water and where it is in large amounts it results in the corrosion of metal pipes and harmful to plant leaf. People who are not accustomed to high chloride content in water are subjected to laxative effect.

Calcium content in water samples of the area ranged in pre and post-monsoon period between 30.46 ppm and 141.08 ppm and 14.42 ppm to 73.74 ppm. The higher concentration of calcium was reported during pre-monsoon in Brahmpuri (141.08ppm in sample no. 17) and minimum (30.46ppm in sample no. 13) from Bhankrota.
Various types of industries are located in Brahmpuri area like garments, storage batteries industries, printing and paint industries etc. the area is densely populated within the old walled city area of the Jaipur. These extremely high values of calcium may be due to return irrigation flow, unscientific use of calcium containing rocks, clay minerals and kankars. Calcium is an essential element for muscular and nervous system, cardiac functions and in coagulation of blood. Low levels of calcium may have adverse effects on human health. Higher content is also harmful resulting in the formation of kidney and bladder stones and irritation in urinary passages.

Magnesium concentration in water sample varies in pre and post-monsoon periods e.g. Oppm-123.3ppm and 9.99ppm to 286.74ppm. In most of the water samples magnesium concentration is found to be under permissible limits. Magnesium is an essential nutrient for human body with an average adult requirement of 200 to 300 mg/l. Magnesium deficiency is associated with structural functional changes and may cause severe diarrhea.

Concentration of sodium in groundwater ranges in pre and most-monsoon between 17.39mg/l-535.64mg/l and 56mg/l to 600mg/l. Higher content of sodium was observed (600mg/l in sample no. 1) in Jalmahal in NE of Jaipur during post-monsoon and lower concentration (17.39mg/l in sample no. 3) in Sanganer area in the south of Jaipur. Water and soil have a higher degree of sodium due to the proximity of many chemical and allied industries.
Though sodium is an essential matter of human body, it's higher content in drinking water may be harmful to persons suffering from cardio and renal diseases pertaining to circulatory system.

The concentration of potassium in ground water samples ranges in pre and post-monsoon period between 0 mg/l to 34.23mg/l and 1.12mg/l to 40.76mg/l respectively. The higher values of potassium were recorded during post-monsoon period in Jalmahal and Amer areas (sample no. 32&33) in the north of Jaipur city. Potassium is less common cation as compared to sodium in water, which may be due to reactions with clay minerals. The main sources of potassium in the study area may be excessive uses of potash fertilizers, weathering of potash silicate minerals, rainwater, returned irrigation flow. Potassium in the form of fertilizers is excessively used in the study area in order to enhance the yield of crops.

The concentration of sulfate in ground water samples ranges in pre and post-monsoon period between 25.51mg/l to 302.86mg/l and 14.41mg/l to 499.38mg/l respectively. The higher values (499.38ppm in sample no. 24) in water samples were recorded at Shastrinagar. The main sources of sulfate in water include sulphate minerals in sedimentary rocks, oxidation of sulphides from igneous and volcanic emanation, and various soil amendments such as gypsum, pyrite fertilizer and rainwater.
The nitrate contents in ground water in study area ranges in between both periods such as 98ppm, to 658ppm and 92ppm, to 642ppm. Nitrate contents of groundwater from study area are much higher than the permissible limits of WHO. Excessive intake of drinking water with nitrate content beyond permissible limit may cause chemical manifestations of diseases called methemoglobinemia (blue baby) in infants, whereas, nitrate content in drinking water is considered important for its adverse health effect. Nitrate can be reduced and absorbed into the blood oxidizing the iron for hemoglobin. It interferes with oxygen transfer and causes cyanosis. Non-convincing evidence of a positive relationship between gastric cancer and consumption of drinking water containing nitrate levels upto 10mg/l have been noticed. It was reported that exposure to dimethylnitrosoumines has produced acute liver damage in men working in industrial laboratories. The main sources of nitrate in the study area are leakage and seepage from sewerage system and soak pits, leak of solid waste disposal management also result in nitrate pollution in ground water, unlined drains which carry effluent and sewerage passing through the city, cattle excreta, use of excessive nitrate fertilizers etc. for gardening may attribute to high nitrates locally.

The bicarbonate and carbonate contents in water under study ranges in between both periods such as 0 mg/l to 286 mg/l and 0 mg/l to 104 mg/l.
The carbonate and bicarbonate contents of water in study area are below the permissible limits and are negligible at some places, which indicate that waters of study area are not contaminated with carbonates and bicarbonates.

Chloride contents in ground water samples of study area in both monsoon periods ranges between 36.92 mg/l to 883.24 mg/l and 25.56 mg/l and 999.68 mg/l. The highest values of chloride were recorded in Jalmahal (999.68 sample no.1 and 24). The chloride content of water is above the permissible limits of WHO. Chlorides are mainly associated with sodium and potassium salts and gives rise to a salty taste in water.

The concentration of fluoride in water samples ranges in pre and post monsoon period 0.52 ppm to 2.65 ppm and 0.04 ppm and 1.8 ppm. The natural environmental pollution due to fluoride in water is a matter of great concern as it leads to serious consequences on human health. The common natural sources of fluoride are calcium fluorides, amphiboles, and volcanic and fumarolic gases. In the study area main sources of fluoride are fluoride salts used in small and large-scale industries manufacturing dye and steel goods. Phosphate fertilizers often contain fluoride as an impurity and are extensively used in the area. The main cause of increase in fluoride content of groundwaters is the fertilizers, industrials wastes and other soil amendments.

Highest value (2.65 ppm in pre monsoon water sample no.3) of fluorides in water was recorded from Sanganer. The surrounding areas also show high values.
Fluorides concentrations in 55% to 60% of water samples is less than the permissible limits. High fluorides level in drinking water gives rise to mottled enamel of the teeth, skeletal fluorosis, and sometimes-severe osteosulerosis whereas deficiency of fluoride causes over acidification of teeth, bones and dental carries. Fluoride reduces solubility of enamel in acid and also acts as inhibitor of bacterial enzymes producing the acids, which attacks the enamel. Fluorides with lower concentrations at an average of 1.0 mg/l are regarded as an essential constituent in drinking water mainly because of its role in prevention of dental carries.

Sodium adsorption ratios of water are plotted on U.S salinity diagram, which gives direct indication of salinity and alkali hazards. The water samples of the area at some places belong to the categories C₃S₁ C₂S₁ and C₃S₂, which falls in the zone of good water quality, but of some places it belongs to categories of C₃S₄ and C₄S₂, which falls within the zone of poor water quality classes. The samples collected from Heerapura, Brahmpuri, Jalmahal, Jagannathpura, fall in poor water quality classes, they have high amounts of nutritional hazards to various crops grown within the area.

The pH values of water samples range in pre monsoon periods as 6.53 to 9.0 and 6.53 to 9.05. Maximum pH of water was recorded at Bhankrota (9.0 in sample no.15) and minimum (6.53 in sample no. 3 and 26) in Brahmpuri area.

Relatively high pH value in water samples of the study area may be partly due to greater salinity in the host rocks and partly to enhanced industrialization.
Graphical methods of hydrochemical facies analysis are an important task in water investigations and compilation and presentations of chemical data in a convenient manner for visual interpretation. In general the tables showing results of chemical analysis of ground water and surface water may be difficult to interpret, particularly where more than a few analysis are involved. To overcome this problem, graphic representations are useful for display purposes, for comparing analysis, and for emphasizing similarities and differences. Graphics can also aid in detecting the mixing of water of different compositions and in identifying chemical process occurring as ground water and surface water moves. A variety of graphic techniques have been developed for showing the major chemical constituents; some of the more useful graphs, which are used in the present study, are first described and illustrated in the following paragraphs.

The vertical bar graphs, widely used in the United States for portraying chemical quality, each analysis appears as a vertical bar having a height proportional to the total concentrations of anions or contains, expressed in milli equivalents per litre. The left half of a bar represents cations and the right half anions.

These segments are divided horizontally to show the concentrations of major ions or groups of closely related ions and identified by distinctive shading patterns.
Circular diagram of water quality with special scale for the ratio so that the area of a circle is proportional to the total ion concentration of analysis sectors within a circle show the fractions of the different ions expressed in milli equivalent per litre.

One of the most useful graphs for representing and comparing water quality analysis is the trilinear diagram by piper (1953). In this diagram cations are expressed as percentage of total cations in milli equivalent per litre, plotted as a single point on the left triangle; while anions, similarly expressed as percentages of total anions, appear as a point in the right triangle. These two points are then projected into the central diamond shaped area parallel to the upper edges of the central area. This single point is thus uniquely related to the total ionic distribution; a circle can be drawn at this point with its area proportional to the total dissolved solids. The trilinear diagram conveniently reveals similarities and differences among ground water and surface water samples because those with similar qualities will tend to plot together as groups.

Furthermore, simple mixtures of water derived from this source can be identified for example, analysis of any mixture of two waters will plot on the straight line AB on the diagram, where A and B are the positions of the analysis of the two component waters. Although these diagrams have generally been used in ground water studies, they have also been successfully used in surface water studies (e.g. Stamatis).
In water samples from the study area, the concentration of cations in most of the sample magnesium are higher than other constituents, among the anions, the concentration of sulphate is higher than other constituents. Though overall concentrations of both cations were low. Sulphate content among anions was high in all samples.

The trilinear diagram represents the concentrations as percentages. In the triangular field at the lower left, the percentage reacting values of the three-cation groups (Ca, Mg, Na) are plotted as single point according to conventional trilinear co-ordinates. Like wise three anion groups (HCO₃, SO₄, Cl) are plotted at the lower right (Fig. 31, 32 and 33). The central diamond field is used to show the overall chemical character of the ground water by single point plotting, which is at intersection of rays projected from the plottings of cations and anions.

Hydro chemical facies diagram presented above are useful for visually describing differences in major ion chemistry in ground water flow system. In order to present water composition in a convenient manner by identifiable groups, Back (1996, 1966), Morgan and Winner (1962) have developed the concept of hydro chemical facies as distinct zones that have cations and anion concentrations describable within defined composition categories, Allen and cherry (1979). According to Back (1961) the term hydro chemical facies is used to describe the bodies of groundwater in an aquifer and differ in their chemical composition. The facies are a function of lithology, solution kinetics and flow pattern of the aquifer (1966).
The percent values of cations and anions were plotted on trilinear diagram (Fig. 31, 32 and 33) as suggested by Morgan and Winner (1962) and Back (1966) in order to designate hydro chemical facies of the study area. The plotting of analytical results show that no dominate facies among the cations was magnesium type, 15 to 20% of the samples were found to fall within sodium type and only one sample was calcium type. Only 12 samples fall in Na & K type facies. Among the anion facies, majority of the samples do not fall in sulphate type facies. The water can be characterized as hard.

The heavy metal contents like Fe, Cu, Zn, Ni, Co, Cr, Pb, Mn, Cd and Hg in water samples at different sampling stations have been discussed in water quality chapter. The prime objectives of the present study is to find out various sources, causes and extent of heavy metal pollution in water bodies in order to suggest measures to prevent or eliminate the pollution hazards and to make the better use of these water bodies for animal, human and agricultural purposes in the study region in the near future. The study also aims to investigate the impact of urban settlements, municipal, industrial and agricultural waste and effluents on the concentration of Fe, Cu, Zn, Ni, Co, Pb, Mn, Cd, Hg, Cr etc. metals in water.

The concentration of Fe in groundwater samples in both periods ranges as 0.038 ppm to 12.9 ppm and 0.03 ppm to 12.95 ppm.
The overall distribution of iron indicate that they are not within the permissible limits due to high industrial activity in the study area, only 12 to 16 samples out of 42 samples fall under the permissible limits for drinking water supplies. High concentration of iron (12.95 ppm in sample no. 13, 12.9 ppm in sample no. 41, 12.2 ppm in sample no. 22) has been observed in Bindayaka, Civil lines and Govindpura areas. The anthropogenic sources of iron of the area include industrial effluents connected with manufacturing of ferromanganese alloys, steel, paint and pigment industries in these particular areas. The corrosion of pipes, pumps and other such structures can also increase to some extent the concentration of iron in water. Fe is an important and essential element for human and exists in the body in the ionic and non-ionic forms.

The concentration of Cu in water samples in the study area varies as 0 ppm to 0.17 ppm and 0 ppm. Overall concentration of copper in the study areas is within the permissible limits of WHO (1984). Copper is an essential metal in human metabolism. Copper is involved in hemoglobin synthesis, connective tissues development and normal functioning of central nervous system. So the low concentrations of copper in the study area are matter of great concern.

Chromium content in ground waters of the study area ranges from 0 mg/l to a maximum 0.082 mg/l. The highest value of chromium (0.082 ppm in sample no. 3) was recorded at Sanganer during pre-monsoon period while during post monsoon period it was absent in the entire samples.
Ingesting large amounts of chromium in drinking water can cause stomach upsets and ulcers, convulsions, kidney and liver damage, and even death.

Concentration of cobalt in pre and post monsoon period in water samples of the study area at various places was observed as 0 ppm to 0.069 ppm and 0 ppm. Traces of cobalt are necessary as a nutrient in plants and animals. Depleting amounts of cobalt in ground water of study area are a matter of concern. Less concentration of cobalt can be attributed to absence of igneous rocks in study area, as cobalt is quite abundant in igneous rocks.

Nickel contents in groundwater sample of the study area in pre and post monsoon periods varies as 0 ppm to 0.018 ppm and 0 ppm. Nickel also occurs preferentially in igneous rocks in association with other ores so nickel is undetectable or in fewer amounts in water samples of the study area.

Zinc content of waters in study area during pre and post monsoon periods varies from zero ppm to 1.1 ppm and 0 ppm to 0.49 ppm. Zinc is an essential constituent in drinking water for human health. The concentration of zinc in ground water samples of study area is below desirable limit prescribed by WHO (1984).

Concentration of cadmium in the study area during pre and post monsoon periods varies as 0.001 ppm to 0.008 ppm and 0.001 ppm and 0.005 ppm. As per WHO standards, permissible limits of cadmium in drinking water is 0.003 ppm and at some places of the study area cadmium content is higher than permissible limit. Long-term exposure to cadmium in water is associated with kidney diseases.
Other long term effects are lung damage and fragile bones, and may have carcinogenic properties. 50% to 60% of the samples show higher values of cadmium.

In the study area mercury concentrations in pre and post monsoon in water samples ranges from 0 ppm 0.44 ppm and 0 ppm. Concentration of mercury in water samples where ever found is much beyond the maximum permissible limit. The highest concentrations of mercury (0.44 ppm in sample no. 4, 0.42 ppm in sample no. 3, 0.40 ppm in sample no. 7) were recorded in the southern and eastern parts of the area. Exposures to high levels of metallic, inorganic, or organic mercury can permanently damage the brain, kidneys, and developing foetus. Effects on brain functioning may result in irritability, tremors, changes in vision or hearing, and memory problems. Industrial effluents seep into the ground water and water resources leading to pollution.

Lead contents in water samples of study area in pre and post monsoon period ranges from 0.004 ppm to 0.2 ppm and 0 ppm to 0.09 ppm. The highest concentration of lead (0.2 ppm in sample no. 23) was recorded at Kho Nagoriyan.

Lead compounds are found in fossil fuels and paints. Lead can affect almost every organ and system in human body. The most sensitive is the central nervous system particularly in children. Lead also damages kidneys and the reproductive system.
Manganese content of water samples from study area during pre and post monsoon period varies as 0.001 ppm to 0.97 ppm and 0 ppm and 0.092 ppm. Manganese is an essential constituent of drinking water in traces upto 0.05 ppm and the analysis of water samples from study area show that manganese content of water in area is under permissible limits.

The quality of ground water as a source of potable water, throughout the world is substandard. All ground waters contain salts carried in solution. The kind and concentration of salts depend upon the environment, movement, and source of the ground water. Salts are added to ground water passing through soils by soluble products of soil weathering and of erosion by rainfall and flowing water. The criteria of water quality may be defined as the concentration quality, or intensive measure that if achieved or maintained, will allow or make possible a specific water use (Mc Cutcheon et. al. 1992). It is necessary to monitor the quality of water in order to ascertain the suitability for certain use.

The successively increasing chemicals in ground water resulting from enhanced discharge of industrial and municipal wastewater has become the major problem affecting water quality.

As a result of pollution, there is an increasing need to treat water before it is suitable for diverse uses like drinking, irrigation, fish farming and recreation to treat wastewater before it is discharged back into the water cycle.

Most cities have areas where the municipal supply runs through pipes laid in the British times with “Birmingham pipes”. They have rusted and have perforations and holes.
Three or four lakes/catchments areas feed large populations. Such centralization is difficult to monitor, with water losses inevitable along the way. The water stored may not be adequate, especially if monsoon fail and wells do not supplement municipal supply. The water table is receding at a greater pace that it is in many parts of the world. So we find boreholes that gave water last year may not give water this year.

In the present study area there is no main river so the load merely on ground water resources. The water resources in the area are limited an extent and load of increasing population; industrialization and irrigation are contributing to a large extent in the further depletion of the sources, and also deteriorating the water quality. The area experience decline in water level at the tune of 0.50 meter to 1.19 meter per year and water quality analysis presented also shows that ground water quality of the area is not suitable for different daily use purposes. Based on a detailed study of the area following controlling measures can be suggested: -

1. Sock pit system of sanitation must be abandoned as leakage from sock pits is a common phenomenon and is a major source of pollution.
2. A proper sewerage system for disposal of waste in the area should be planned.
3. Unlined drains carrying sewerage/effluents should be lined urgently.
4. Nitrate fertilizers like urea may furnish significant quantum of nitrate constituents. Used of these fertilizers for gardening, etc. Should be discouraged.

5. Farm animals produce considerable amount of nitrogenous organic waste that tends to concentrate at place where large number of animals are confined. It is suggested that these dairy farms should be shifted to some other places.

6. Plantation not only balances microenvironment system but also is likely to reduce pollution levels. Therefore plantation and vegetation should be encouraged.

7. Artificial recharge schemes can be utilized for recharging groundwater as the water levels are declining rapidly in the area.

8. Common people for drinking purposes should mark all the ground water abstraction structures including hand pumps with high nitrate and fluoride concentration so as to avoid their utility.

9. Urban water suppliers should introduce dual water supply bringing fresh water supply schemes to the affected areas from other areas for drinking purposes.

10. High nitrate and fluoride waters of the affected areas can be supplied separately for other domestic purposes like washing, cleaning, bathing etc.

11. Alternative sources of fresh drinking water must be evaluated where water is free from pollution.

12. Alternative matter of chemical dye used in dyeing industries can be replaced by such dyeing matter, which should not contain fluoride.
13. Awareness among the public and other NGO’s about the adverse effects of chemical contaminant should be encouraged.

14. The public should be made aware of the importance of hygiene, the dangers of pollution, and benefits of environmental preservation.

15. Available technologies for the treatment of water should be evaluated and cost effective and eco-friendly technologies adopted. Technologies like distillation; filtration and duckweed can be utilized for treating water at home.