UNESCO-IUCN Enhancing Our Heritage Project:
Monitoring and Managing for Success in Natural World Heritage Sites

Technical Report No. 09

Water Quality Assessment in and around Keoladeo National Park, Bharatpur, Rajasthan

IUCN
The World Conservation Union

UNITED NATIONS FOUNDATION

Project Team

Dr. V.B Mathur
Professor & Project Coordinator

Sh. B.C. Choudhury
Professor & Project Co-cordinator

Sh. P.R. Sinha
Director, WII & Project Leader

Associate Consultant

Ms. Ritu Singh

Contents

Background

'Water Quality Assessment in and around Keoladeo National Park' has been undertaken under the project "Enhancing Our Heritage: Monitoring and Managing for Success in World Natural Heritage Sites". The project aims to demonstrate how using an assessment, monitoring and reporting framework can enhance effective management of protected areas. Integration of assessment and monitoring practices into the general process of management is one of the key objectives of the programme. For this reason, water quality assessment in and around Keoladeo National Park has been taken up.

Further, wetlands occupy significant area of Keoladeo National Park, Bharatpur. These are most important ecosystem of the national park as these provide habitat for local and migratory birds as well as for turtles, fishes, snails etc. Wetlands are among the world's most productive environments and provide a wide variety of benefits. They are cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend for survival.

The interactions of physical, biological and chemical components of a wetland, such as soils, water, plants and animals, enable the wetland to perform many vital functions, for example: water storage; storm protection and flood mitigation; shoreline stabilization and erosion control; groundwater recharge; groundwater discharge; water purification through retention of nutrients, sediments, and pollutants; and stabilization of local climate conditions, particularly rainfall and temperature.

Wetlands being 'wet-lands', water is the most important defining component in structuring ecological character of wetlands. Changes in water quality can alter the whole ecosystem affecting all dependent floral and faunal species as well as human settlement around the wetlands. High quantities of nutrients entering the systems results in high productivity and may result in 'choking' of wetlands whereas too little nutrients might result in very low growth, thus, affecting herbivores both birds and animals. Similarly, high amount of pesticides in the water entering the wetlands may result in mortality of birds and animals.

It, therefore, is imperative to monitor water quality. Assessment and monitoring provides insights for better management. Present Assessment study aims to:

- Form baseline data for future monitoring
- Provide information on significance of components monitored – fluctuations or drastic digression in which would require management interventions
- Establish monitoring protocols for future monitoring
- All the above to feed into effective adaptive management of the protected area

Methodology

Water samples were collected from in and around Keoladeo National Park, Bharatpur, on a monthly basis. *Monitoring of surface water cannot be undertaken as the area is dry*. For purpose of groundwater monitoring the area is divided into three zones, these are:

a) Zone 1: inside the wetland

b) Zone 2: 500m to 1500m away from the boundary of the wetland

c) Zone 3: more than 1500m away from the boundary of the wetland

3nos. samples were to be collected from each zone and preserved for analysis.

These were then analysed in the laboratory at WII, Dehradun as well as in field using portable water quality monitoring kits. Parameters to be analysed are: pH, Electrical conductivity, salinity, sodium, potassium, hardness, chlorides, fluorides, calcium and magnesium, nitrates, phosphates, lead, iron, zinc, copper, and mercury. Of these, samples could not be analysed for heavy metals and calcium, magnesium, fluorides due to lack of chemicals used in analysis and other such like restrictions.

Prescribed standard methods were used to analyse the samples in the laboratory and direct reading instruments as field kits shall be used in the field for analysis. The data thus recorded is being presented here, in the pre-final report. As this has been a dry season for the national park it is not possible to analyse surface water in the current study but as and when the wetlands get flooded in the following years the study should be repeated to form a complete data-base.

Monitoring physicochemical indicators of wetland water

Aquatic organisms are sensitive to changes in the physical and chemical (physiochemical) characteristics of the water they live in. Most organisms experience a decrease in reproduction and increase in mortality when the physiochemical condition of the water exceeds maximum and minimum values. Each aquatic species does best within that species specific range. By definition, water quality is considered degraded when physiochemical conditions change so that many types of organisms are negatively effected. The result is usually a decrease in diversity of both plants and animals, and a shift to the development of an aquatic system where only a few pollution tolerant species predominate.

Our program is designed and equipped to measure several standard physiochemical indicators of wetland water quality: temperature, acidity, conductivity, and nutrient levels. These indicators can tell us a lot about wetland health. However, aquatic systems can be degraded and aquatic organisms impacted by many other factors that are beyond the scope of this study. These environmental contaminants include, among others, heavy metals (mercury, selenium, etc.) and toxic organic chemicals (pesticides, solvents, gasoline, etc.).

Assessing water quality by using physiochemical indicators is very useful, but it is not enough in itself. Since plants and animals are influenced by multiple physiochemical parameters simultaneously, and these factors can have synergistic effects (impacts on organisms greater than the additive effects of each factor), the water quality of a stream from an organism's point of view might be worse than it appears from physiochemical measurements alone. It is therefore important to measure various biological parameters as well as pollutants. These are however, beyond the scope of this project study.

Relevance of various parameters analysed in the wetland system

Several parameters are important for functioning of a healthy aquatic ecosystem. These could be grouped as physical, chemical and biological. In Keoladeo National Park wetland most biological parameters act as indicators of a healthy ecosystem. For eg. formation of a good heronry, large congregations of migratory water fowl etc. these in turn are dependent on optimum physical, chemical and biological conditions of wetland surface water. Further, the wetland recharges groundwater in adjacent areas as well, improving its quality that makes it potable for anthropogenic use.

Physical parameters analysed and monitored are pH, Electrical Conductance, Total Dissolved Solid (TDS), Dissolved Oxygen (DO). Chemical parameters of relevance are ions, nutrients, and heavy metals. Biological parameters include primary productivity, species richness and composition including planktons as well as higher organisms, etc.

This report limits itself to physico-chemical parameters of water, biological parameters are out of the scope of present study.

1. Physical Parameters

a. pH

The pH test measures the hydrogen ion concentration of water. It provides a gauge of the relative acid/base nature of a water sample. A pH of 7 is considered to be neutral. Substances with pH less than 7 are acidic; substances with pH greater than 7 are basic. The scale is logarithmic, thus there is a ten-fold change in acidity or alkalinity per unit change. For example, water with a pH of 5 is ten times more acidic than water with a pH of 6.

The pH of water determines the solubility and biological availability of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium, etc.). For example, in addition to affecting how much and what form of phosphorus is most abundant in the water, pH also determines whether aquatic life can use it. Metals tend to be more toxic at lower pH, because they are more soluble.

Optimal Levels

- pH values between 7.0 and 8.0 are optimal for supporting a diverse aquatic ecosystem.

- A pH range between 6.5 and 8.5 is generally suitable.

Acid conditions are highly detrimental to aquatic macroinvertebrates and fish. If pH declines below 6.5, few eggs hatch and aquatic insect levels drop.

Expected Impact of Pollution

When pollution results in higher productivity, for example, from increased temperature or excess nutrients, pH levels increase. Although these small changes in pH are not likely to have a direct impact on aquatic life, they greatly influence the availability and solubility of all chemical forms and may aggravate nutrient problems.

b. Electrical Conductivity

Electrical Conductivity is a measure of the capacity of water to conduct an electric current. A higher value of conductivity means that the water is a better electrical conductor. The unit of measure for conductance can be expressed in two ways:

- **microSieman per centimeter of water measured at a temperature of 25 degrees Celsius** (abbreviated **μS/cm @ 25° C**).
- **Micromhos per centimeter** (abbreviated **micromhos/cm** or **μmhos/cm**).

The amount of dissolved salts in water will affect the conductivity of electricity. The more dissolved mineral salts, the higher the conductivity. This is because of the presence of dissolved ions from the mineral salts. Conductivity is also increased by higher temperatures. Although the conductivity of water will not tell us which mineral salts are present, this measure gives us an index of their level. High levels of mineral salts in fresh waters can affect animal and plant survival and reproduction.

The Role of Electrical Conductivity in Waterbodies:

Electrical conductivity increases when more of any salt including the most common one, sodium chloride, is dissolved in water. For this reason, conductivity is often used as an indirect measure of the salt concentration in waterbodies. In general, waters with more salts are the more productive ones - except, of course, where there are limiting nutrients or limiting environmental factors involved. Natural factors can also cause higher conductivity values in the open water. For example, drought conditions can increase the salt concentrations in a waterbody in two ways: (1) drought can cause inflowing waters to have higher salt concentrations, and (2) heat and low humidity can increase the rate of evaporation in open water, leaving the waterbody with a higher concentration of salt. Because animal and human wastes (sewage, feed lot effluent, etc.) contain salts, the measurement of conductivity can be used for the detection of contamination. It's important to keep in mind that elevated conductance measurements may have various causes and do not by themselves prove there is contamination from human or animal wastes.

c. Total Dissolved Solids

The total amount of ions in the water is called the **TDS** (total dissolved salt, or total **dissolved solids concentration**). Both the concentration of TDS and the relative amounts or ratios of different ions influence the species of organisms that can best survive in the waterbody, in addition to affecting many important chemical reactions that occur in the water.

d. <u>Dissolved Oxygen</u>

Like terrestrial animals, fish and other aquatic organisms need oxygen to live. Oxygen can be present in the water, but at too low a concentration to sustain aquatic life. Dissolved oxygen (DO) is a critical water quality parameter indicating the health of an aquatic system. DO is the measurement of oxygen dissolved in water and available for fish and other aquatic life.

Optimal Levels of Dissolved Oxygen		
Optimal	**Acceptable**	**Poor**
9 *mg/l*	7-8 mg/l	3.5-6 mg/l
Levels below 3.5 mg/l are likely fatal to freshwater fishery.		
Generally, a DO level of under 5 mg/l is stressful to most vertebrates and cause mortality to some invertebrates.		

Reasons for Natural Variation

Oxygen is produced during photosynthesis of plants and consumed during respiration and decomposition. Because it requires light, photosynthesis occurs only during daylight hours. Respiration and decomposition, on the other hand, occur 24 hours a day. This difference alone can account for large daily variations in DO concentrations. DO concentrations steadily decline during the night and are the lowest just before dawn, when photosynthesis resumes. **Always measure DO at the same time of day.** Other sources of oxygen include the air and inflowing water sources. More oxygen dissolves into water when wind stirs the water. Rivers and streams deliver oxygen, especially if they are turbulent. Turbulence mixes water and air (aeration).

Another physical process that affects DO concentrations is the relationship between water temperature and gas saturation. Cold water can hold more gas - that is DO - than warmer water. Warmer water becomes "saturated" more easily with oxygen.

Seasonal changes also affect dissolved oxygen concentrations. Warmer temperatures during summer speed up the rates of photosynthesis and decomposition. When all the plants die at the end of the growing season, their decomposition results in heavy oxygen consumption.

Relationship between Temperature and Oxygen Solubility	
Temperature degrees C	**Oxygen Solubility (*mg/L*)**
O	14.6
5	12.8
10	11.3
15	10.2
20	9.2

From this you can see: the colder the water temperature, the greater the level of dissolved oxygen and why it is important to take the temperature and DO measurements at the same time.

Expected Impact of Pollution

To the degree that pollution contributes oxygen-demanding organic matter (like sewage or lawn clippings) or nutrients that stimulate growth of organic matter, pollution causes a decrease in average DO concentrations.

2. Chemical Parameters

a. Ion Balance

Ion balance means the sum of the negative ions equals the sum of the positive cations when expressed as equivalents. These ions are usually present at concentrations expressed as mg/L (parts per million, or p**pm**) whereas other ions such as the nutrients phosphate, nitrate, and ammonium are present at µg/L (parts per billion, or **ppb**) levels. a lake contains a wide array of molecules and ions from the **weathering** of soils in the **watershed**, the atmosphere, and the lake bottom. Therefore, the chemical composition of a lake is fundamentally a function of its climate (which affects its **hydrology**) and its **basin** geology. Each lake has an **ion** balance of the three major **anions** and four major **cations** (see Table below).

Anions	**Percent**	**Cations**	**Percent**
HCO_3	73%	Ca^{2+}	63%
SO_4	16%	Mg^{2+}	17%
Cl	10%	Na^+	15%
		K^+	4%
Other	<1%	Other	< 1%

Table: Ion balance for fresh water

Lakes/waterbodies with high concentrations of the ions calcium (Ca+2) and magnesium (Mg+2) are called **hardwater waterbodies**, while those with low concentrations of these ions are called **softwater waterbodies**. Concentrations of other ions, especially **bicarbonate**, are highly correlated with the concentrations of the hardness ions, especially Ca+2. The ionic concentrations influence the aquatic system's ability to assimilate pollutants and maintain nutrients in **solution**. For example, calcium carbonate (CaCO3) in the form known as **marl** can precipitate phosphate from the water and thereby remove this important nutrient from the water.

Ions

Sodium

Sodium is the sixth most abundant element on earth. Sodium is often associated with chloride; common table salt is mostly sodium chloride. All waters contain sodium. Sodium is essential to all animals and some microorganisms and plants. Generally, sodium is not considered a limiting factor for freshwater organisms, unless sodium concentrations reach levels at which freshwater organisms cannot survive. As sodium concentrations increase in a waterbody, there can be a continuous transition from freshwater organisms to those adapted to brackish water and then ultimately, to marine (saltwater) organisms.

Potassium

Potassium is an important mineral and a nutrient necessary for plant growth. It's found in many soils and constitutes a little over 2% of the earth's crust. Natural sources of potassium are numerous in aquatic environments. Man-made sources include industrial effluents and run-off from agricultural areas. (Potassium is used extensively in crop fertilizers.)

The Role of Potassium in Waterbodies:

Because potassium salts are readily soluble in water, potassium is found primarily in dissolved form in waterbodies rather than in particulate form.

The concentration of potassium in natural surface water is generally less than 10 mg/L, but potassium concentrations as high as 100 mg/L can occur. Potassium is essential to plant and animal nutrition. Because potassium concentrations in freshwaters are generally adequate for meeting the nutritional needs of the biological community, potassium is not usually considered as being a limiting nutrient like phosphorus and nitrogen.

Calcium

Calcium is a mineral that dissolves easily in water. The chemical symbol for calcium is "Ca." It is one of the most abundant substances in surface waters and ground waters.

Freshwaters around the world have higher concentrations of calcium when they are located closer to calcium-rich soils and rocks. Typical calcium concentrations worldwide are less than 15 mg/L, but waters close to calcium-rich carbonate rocks often have calcium concentrations exceeding 30 mg/L. Calcium enters the aquatic environment primarily through the weathering of rocks like limestone, which is largely composed of calcium compounds. In some circumstances, calcium can also be deposited in waterbodies as a result of human activities, often because of the extensive use of calcium-containing chemicals in agriculture and industry.

The Role of Calcium in Waterbodies:

Calcium has been shown to influence the growth of freshwater plants and animals. It is a necessary structural component of plant tissues, animal bones, and animal shells. Calcium is involved in many chemical cycles that occur in waterbodies, often in rather complex ways.

Magnesium

Magnesium is the eighth most abundant natural element on earth and is a common component of water. Magnesium is found in many geologic formations, including dolomite. It's an essential nutrient for all organisms and is found in high concentrations in vegetables, algae, fish, and mammals.

The Role of Magnesium in Waterbodies:

Natural sources contribute more magnesium to the environment than do all human activities combined. Magnesium is found in algal pigments (known as chlorophyll) and is used in the metabolism of plants, algae, fungi, and bacteria. Freshwater organisms need very little magnesium compared to the amount available to them in water. Because there is such little biological demand for magnesium compounds and because they are highly soluble, magnesium concentrations in waterbodies fluctuate very little. Elevated (high) magnesium concentrations, can cause water to be designated as "hard" water.

Carbonates and bicarbonates

Carbonate ion ($CO3^{-2}$) is far less common in natural waters than is the bicarbonate ion, because it exists only at higher pH values (pH > 8.3).

Bicarbonate ion ($HCO3^-$) is more common in waters draining from watersheds that contain carbonate rocks such as limestone and dolomite, but carbonates may also be present in other sedimentary rocks such as shales and sandstones. Carbonates are far less common in igneous and metamorphic rocks, although they may occur here as well, especially in the marbles (metamorphic) and the carbonatites (igneous). Bicarbonate ion is the most common anion in most natural freshwaters, and is the chief source of alkalinity in such waters. Bicarbonate ion levels are generally expressed in terms of calcium carbonate equivalent and are determined as part of the alkalinity procedure.

Bicarbonate is an important source of carbon for higher aquatic plants and algae, although the aquatic mosses cannot use it as a carbon source. When bicarbonate is used by aquatic plants, it tends to raise water pH because a hydroxide ion is released in the process of extracting carbon dioxide from the bicarbonate ion.

(1) $HCO3^-$ ---------> $CO2 + OH^-$

Sulfates

Sulphates are chemical compounds that contain the elements sulfur and oxygen. They are widely distributed in nature and can be dissolved into waterbodies in significant amounts.

There are a variety of diverse sources for sulfates in waterbodies. Sulfate concentrations in a waterbody are influenced primarily by natural deposits of minerals and organic matter in its watershed.

The Role of Sulfur in Waterbodies:

Sulfate is used by all aquatic organisms for building proteins. Sulfur changes from one form to another (known as “cycling”) in quite complex ways. Sulfur cycling can influence the cycles of other nutrients like iron and phosphorus and can also affect the biological productivity and the distribution of organisms in a waterbody. Bacteria can significantly influence the sulfur cycle in water. For example, under conditions where dissolved oxygen is lacking, certain bacteria can convert sulfate to hydrogen sulfide gas (H2S). Hydrogen sulfide gas has a distinctive rotten egg smell, and in high concentrations can be toxic to aquatic animals and fish.

b. <u>Nutrients</u>

Nutrients in water serve the same basic functions as nutrients in a garden. They are essential for growth. In a garden, growth and productivity are considered beneficial, but this is not necessarily so in water. The additional algae and other plant growth encouraged by the nutrients may be beneficial up to a point, but may easily become a nuisance. The main nutrients of concern are phosphorus and nitrogen.

Phosphates and nitrates are associated with many nonpoint pollution sources, such as livestock manure and urine, failing septic systems and synthetic fertilizers. (Synthetic fertilizers release their nutrients more rapidly than the slower-acting organic ones like compost and composted manure.) Excessive nutrient loads can artifically stimulate plant growth resulting in algal blooms which speed up the aging process of aquatic systems.

Nitrogen

Nitrate ion ($NO3^-$) is usually not present in large amounts in unpolluted waters, but may reach high values in some groundwaters, and in waters polluted by agricultural or industrial wastes. The nitrate ion represents the most highly oxidized state of Nitrogen (N^{+5}) found in water. Nitrogen may take other forms in aquatic systems as well. The most common of these are the nitrite ion ($NO2^-$) and ammonia (NH3 or $NH4^+$). Other forms such as hydroxylamine (NH2OH), and organic forms (such as amino acids and proteins) occur as well. Under oxidizing conditions, ammonia is oxidized to nitrite and then to nitrate. Under reducing conditions, nitrate is likely to be reduced to nitrite, and then to nitrogen gas. All of these oxidations and reductions are largely carried-out by specific bacteria in water. Some aquatic bacteria can use nitrate as a terminal oxygen acceptor in respiration (in place of oxygen which more usually plays this role), and thus carry out essentially aerobic respiration in anaerobic environments

Groundwaters which contain significant amounts of nitrate (>10 mg/l) may constitute a health hazard to young children, in which nitrate ingestion may produce a condition called **methemoglobinemia** which may cause mental retardation or even death.

Nitrite ion ($NO2^-$) in water is usually due to the oxidation of ammonia or the reduction of nitrate ion (see above). Nitrite levels in unpolluted waters are generally low.

Phosphorous

Phosphorus ionic species ($PO4^{-3}$, or $HPO4^{-2}$, or $H2PO4^-$) are important biologically because Phosphorus, while an important macronutrient element, is not very abundant in the Earth's rocks. Usually, phosphate is measured as the orthophosphate ion ($PO4^{-3}$), with other phosphate forms (meta- or polyphosphates) and organic phosphorus compounds being converted to orthophosphate by chemical pretreatment. Phosphorus occurs naturally as the mineral apatite in igneous rocks, and as "phosphate rock", a chemical sedimentary rock. Phosphates are also used widely in cleansing agents and in water and wastewater treatment. In natural waters, phosphates are often precipitated as insoluble metallic phosphates (eg. iron and aluminum phosphates). There are also frequently precipitated as a component of organic detritus.

c. <u>Salinity</u>

Salinity is the saltiness of water and is influenced by leaching rock and soil formations, runoff from a watershed, atmospheric precipitation and deposition, and evaporation. It is measured in units of parts per thousand (abbreviated "ppt"). Salinity often tends to be lower in areas receiving inflows of freshwater, like the mouths of rivers. Salinity often tends to be higher in areas where the evaporation rate is high —in hot, dry climates.

Chloride

Chloride is a substance found in all the world's waters. Chloride is an ionized form of the element chlorine. Chloride compounds are used extensively in industrial operations and agriculture. For example, the potash in fertilizer is potassium chloride. Common table salt is sodium chloride and is a necessary part of human and animal diets.

Chloride levels in waterbodies are affected by several factors. Climate is a major influence. For example, chloride concentrations in waterbodies in humid regions tend to be low, whereas those in semi-arid and arid regions may be hundreds of times higher because of higher rates of evaporation.

The Role of Chlorides in Waterbodies:

Salts are the primary sources of chloride in water. (Note that the term "salt" includes compounds in addition to sodium chloride.) Traveling by many pathways, chloride has found its way into all the world's waters. The saltiness, or chloride concentration, of water can affect plants and wildlife. For example, some species die in water that is too salty, and others die in water that is not salty enough.

Water Quality in and around Keoladeo National Park, Bharatpur

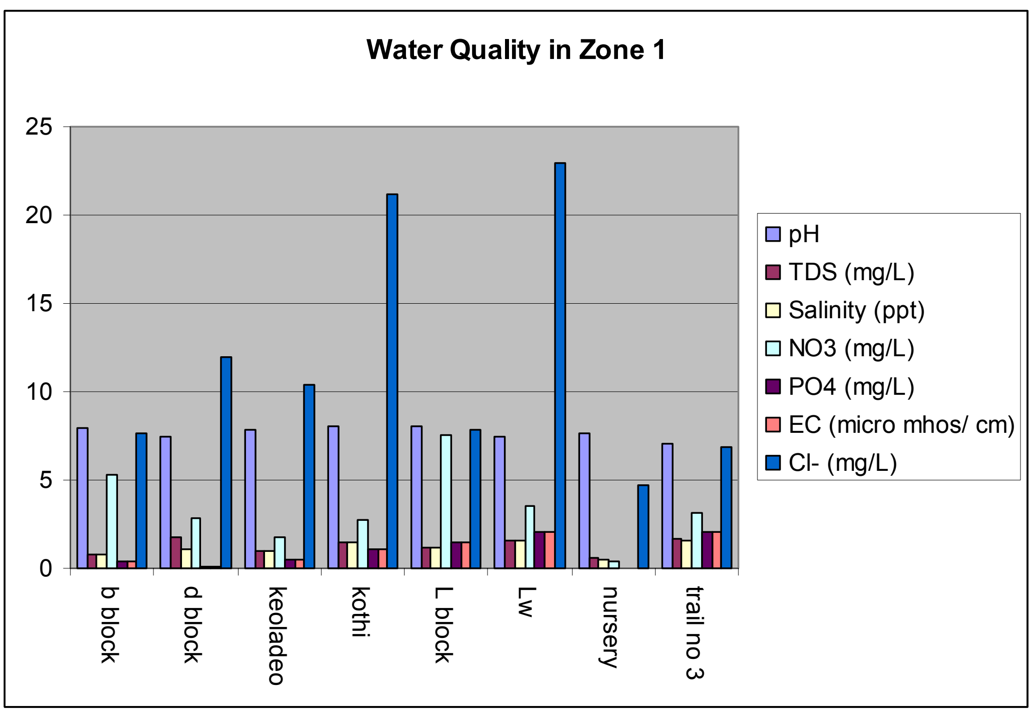
Surface Water

Sampling Point	NO3 (mg/L)	PO4 (mg/L)	Cl- (mg/L)
Keoladeo Diggi	3.27	0.25	13.916
E-block Surface	2.33	0.201	16.66

Groundwater

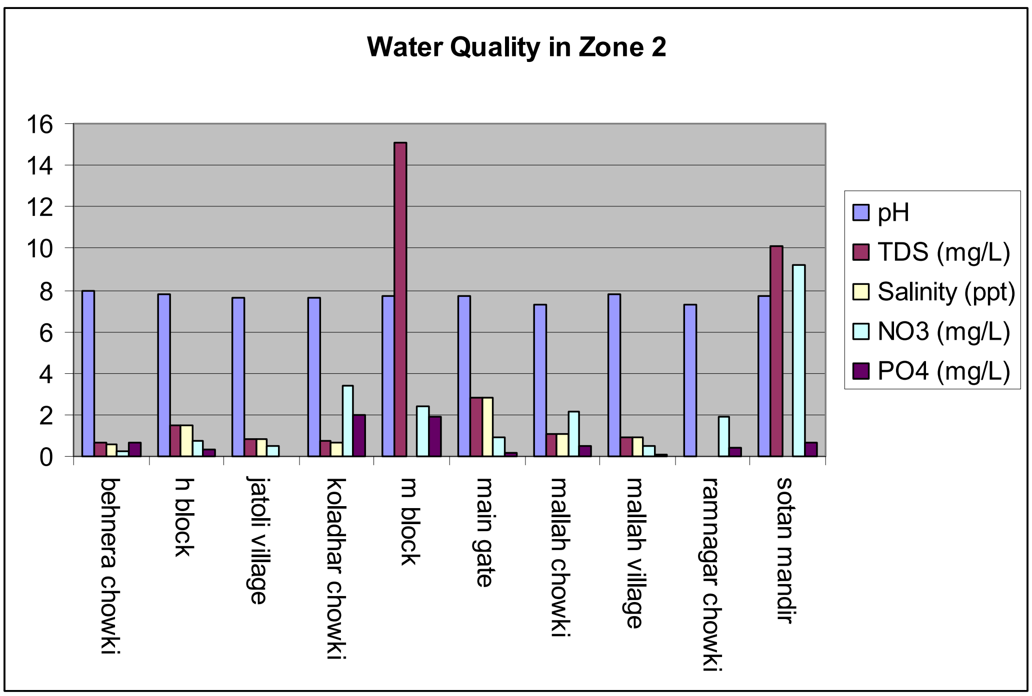
ZONE 1 (inside or near the wetland)

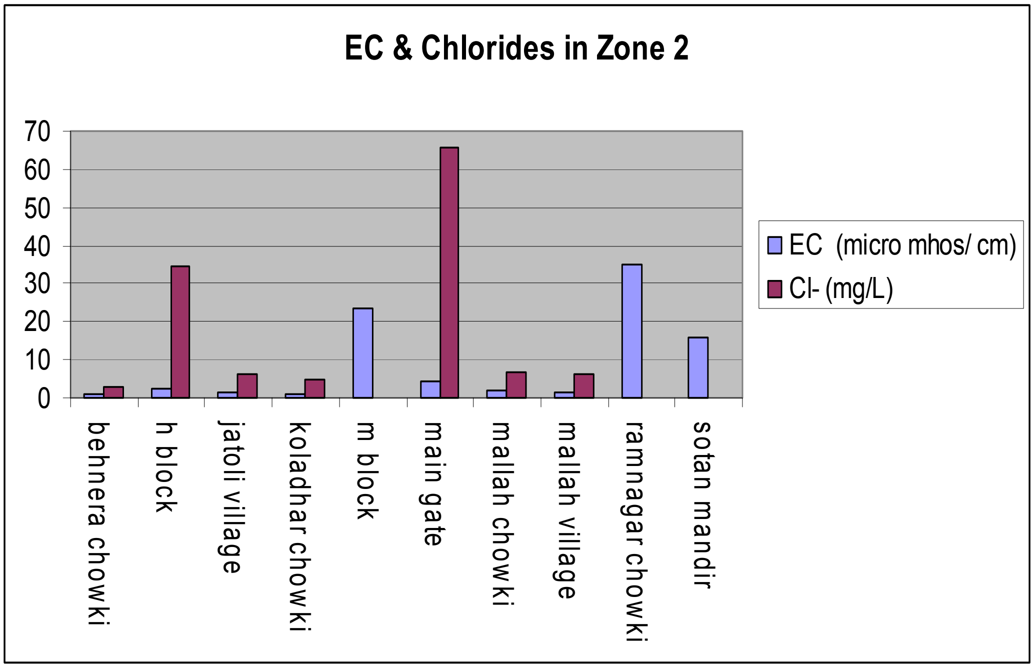
Sample point	pH	TDS (mg/L)	Salinity (ppt)	NO3 (mg/L)	PO4 (mg/L)	EC (micro mhos/ cm)	Cl- (mg/L)
B Block	7.93	0.83	0.8	5.305	0.377	0.377	7.644
D Block	7.42	1.74	1.12	2.807	0.097	0.097	11.956
Keoladeo	7.86	0.98	1	1.752	0.502	0.502	10.388
Kothi	8	1.5	1.5	2.703	1.072	1.072	21.16
L Block	8.02	1.18	1.2	7.55	1.441	1.441	7.84
Lw	7.5	1.61	1.6	3.544	2.054	2.054	22.932
Nursery	7.6	0.54	0.5	0.424	0.003	0.003	4.704
Trail No 3	7.06	1.62	1.53	3.183	2.043	2.043	6.86



<u>ZONE2</u> (1-1.5 km away from edge of wetland)

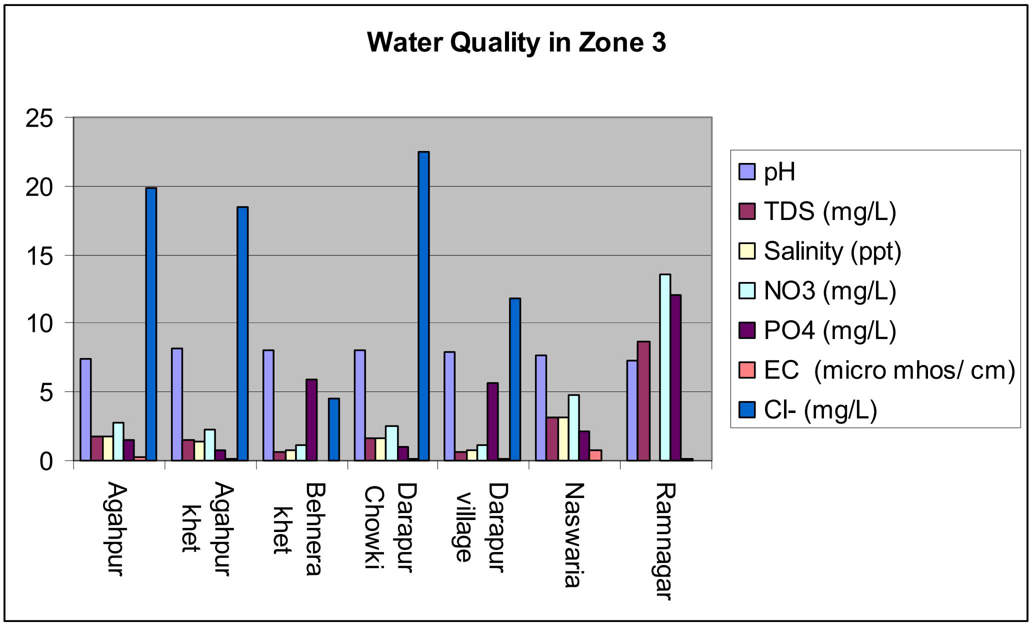
Sample Point	pH	TDS (mg/L)	Salinity (ppt)	NO3 (mg/L)	PO4 (mg/L)	EC (micro mhos/ cm)	Cl- (mg/L)
Behnera Chowki	7.93	0.63	0.6	0.246	0.661	0.98	2.744
H Block	7.8	1.5	1.5	0.784	0.296	2.3	34.3
Jatoli Village	7.6	0.84	0.8	0.533	0.032	1.29	6.272
Koladhar Chowki	7.62	0.71	0.7	3.374	2.008	0.9	4.9
M Block	7.68	15.05		2.37	1.936	23.4	442.96
Main Gate	7.7	2.78	2.8	0.872	0.131	4.26	65.66
Mallah Chowki	7.3	1.1	1.1	2.142	0.457	1.7	6.664
Mallah Village	7.82	0.93	0.9	0.527	0.06	1.44	6.272
Ramnagar Chowki	7.3			1.875	0.453	35.2	OVERRANGE
Sotan Mandir	7.74	10.11		9.215	0.646	15.8	274.4





<u>ZONE 3</u> (>1.5 km away from edge of wetland)

Sample Point	pH	TDS (mg/L)	Salinity (ppt)	NO3 (mg/L)	PO4 (mg/L)	EC (micro mhos/ cm)	Cl- (mg/L)
Agahpur	7.38	1.81	1.8	2.82	1.555	0.238	19.796
Agahpur Khet	8.2	1.45	1.4	2.26	0.73	0.064	18.424
Behnera Khet	8	0.69	0.7	1.07	5.959	0.036	4.508
Darapur Chowki	8.1	1.59	1.6	2.47	1.038	0.148	22.54
Darapur Village	7.9	0.69	0.7	1.07	5.661	0.084	11.76
Naswaria	7.62	3.09	3.1	4.79	2.114	0.794	57.232
Ramnagar Village	7.3	8.68	overrange	13.57	12.079	0.073	178.36



Conclusion

Concentration of chlorides and other ions in all the regions shows an increase with time, chlorides almost doubling in places from January to April with corresponding increase in TDS [Total Dissolved Solids].

A region towards west of the wetland seems to have saline patches in substratum and has unusually high salinity and chlorides in ground water.

Recommendations

- Monitoring of water quality through physico-chemical analysis using field-kits should be done at regular intervals monthly.

- Parameters to be monitored and recorded are- temperature, pH, Dissolved Oxygen, Total Dissolved Solids, Electrical Conductivity, Salinity, Calcium, Magnesium, Carbonates, Bicarbonates, Sulphates, Nitrates, Phosphates and Chlorides.

- As this report furnishes pre-monsoon data, it is recommended that the first year data [i.e., 2005-2006 year] be recorded precisely and timely so as to ensure extensive data for the periods of post monsoon and draw-down phase of the wetland.

- Samples should always be collected with utmost care and early in the morning, particularly for Dissolved Oxygen parameter. This would give lower, therefore critical, levels of dissolved oxygen in the water. For recording higher values for diurnal fluctuation in dissolved oxygen samples are to be collected and analysed at 3 p.m.

- If the samples are not being analysed on site, proper sample bottles should be used.

- Proper care should be taken for maintenance of equipment. Probes of direct reading instruments should be kept safely and dipped in appropriate chemicals. These chemicals should be procured regularly to ensure long time use of the equipment.

- Significant fluctuations in readings – particularly of salinity, total dissolved solids and chlorides call for management interventions – particularly during breeding season. Though a gradual increase in concentration of ions occurring towards summer season is a natural phenomenon related to quicker evaporation from water bodies.