PERILS OF EUTROPHICATION AND SPATIO-TEMPORAL DYNAMICS OF LAKE KALAR KAHAR , POTOHAR PLEATUE, SALT RANGE, PAKISTAN

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ABSTRACT : *Lake Kallar Kahar with an altitude of about 1500' above mean sea level is located in the southern hilly area of Potohar Plateau in the Salt Range. It is a shallow lake, thus natural vegetation can be seen in the middle as well as all around the lake. Because of the abode of a number of migratory birds, fishing and boating activity lake has become a prominent tourist spot and a distinctive wetland. Though, lake is facing environmental degradation due to the rise of agricultural practices to supply food for rapidly growing population, un planned tourism and hunting practices are some of the probable pressures towards conservation. Identification of drivers liable for deterioration in water quality, biodiversity and increased anthropogenic pressures in lake conservation perspective is highlighted. The current study is aimed to highlight spatio-temporal dynamics of eutrophication of water quality, biodiversity as well as the potential sources of the diverse turbidity in the Lake. The eutrophication of the lake is realized to be higher, signifying an increasing deterioration of quality of the lake water both physical and biological. It is because of the incoming untreated sewage water from the food court situated in the south and surface water runoff produced from inhabited area in the north and western periphery of the lake. Cumulative tendency of the contamination, the chemical quality of the lake water is quite alarming, it differs significantly over the years. Likewise, the turbidity is subjugated by dissolved coloured and suspended sediment load [12] in the Lake's northern part. Pollution in the lake water is a big menace for the migratory birds and reduced storage capacity due to sedimentation. The outcomes will provide reliable beginning for advance research in the existing loading extent together with nutrients and sediments. Moreover, it will expedite sustainability to the functions of the lake ecosystem and certify community's reliability [14]. The study pattern will be developed by using GIS/RS techniques; a comprehensive study is suggested for recommending a plan to revitalize the lake and its watershed.*

Keywords: eutrophication, spatio-temporal analysis, water contamination, degradation of wetland, Lake Kalar Kahar

INTRODUCTION

Many developing regions suffer from either chronic shortages of freshwater or the pollution of readily accessible water resources [12]. According to a recent UNICEF report, about 800 million people in Asia and Africa are living without access to safe drinking water. Consequently, this has caused many people to suffer from various diseases. The quality of drinking water is of vital concern to mankind, since it is directly associated with human life. Fecal pollution of drinking water causes water-borne diseases, which wiped out entire population of cities [4[. According to the special report of United Nations on Iran, the population is exposed to higher risks of enteritis, diarrhea and contagious diseases, due to non-availability of drinking water in rural areas [18]. Water is particularly important as it accounts for about 88% safe drinking water in rural areas, where population is widely dispersed and the infrastructure needed for treatment and transportation of surface water does not exist. Unfortunately, the availability of pure water is limited. There are many sources that contribute contaminants to the water, e.g., land disposal of solid wastes, sewage disposal on land, agricultural activities, urban runoff and polluted surface water. The suitability of ground water has been examined with reference to World Health Organization and National Environmental Quality Standards [23, 15]. An attempt has also been made to classify the water on the basis of different classification parameters.

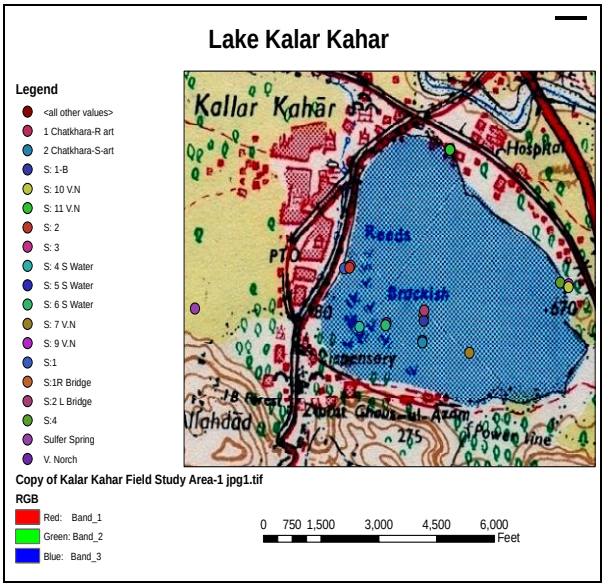

Figure: 1 Location map of Kalar Kahar Lake and surroundings, Salt Range, Pakistan representing sampling points (Adopted from Survey of Pakistan Topographic Map No. 43 D/9, 1997)

Kalar Kahar Lake (32°46'N, 72°42'E ;) circumference is 4.25km covering an area of 220 ha. with elevation of 639m amsl (Figure.1) is a legendary tourist's spot. It is one of the unique wetland located in Salt Range of Pakistan where every year thousands of migratory birds from Central Asia enjoy

shelter for 3-4 months from late November to March. An estimate of about 2,000 ducks and cocks was recorded during winters of 1973, 1974 followed by 5,000 1983, 1984, < 150 in January 1987 and presently there is no entry of migratory birds [24]. Reported by Pakistan Meteorological Department, It falls within dry subtropical climate with an annual rainfall between 600mm and relative humidity of 20% to 85% while minimum temperature in January is 1 to 5 ^{0}C and maximum temperature in June is 40◦C to 45◦ C.

Forest covers an area of 155425 acres in surroundings of the Kallar Kahar. There are a number of fresh water springs which are used to irrigate land and also a perennial source of recharge for the Lake. After the construction of motorway during year 2000, the Lake has gained special importance. To meet the increased requirements of the tourists the Government initiated several measures such as increase of parking area, construction of new markets in private sector for providing food and other picnic items. Large scale excavation and mining activities in the mountain slopes located in south east of the Lake are under progress since 2008. These excavations are being made to develop terraces for the construction of residential housing colony and development of commercial markets nearby lake. As a result of these excavations, the soft geological formations are exposed to the environment. During the heavy precipitation of monsoon season, large scale sediments are being transported from these erodible formations and deposited in the lake, As a result total storage capacity of the lake has been greatly affected.

Conservation and sustainable development of the Lake watershed for migratory birds, healthy tourism as well as revitalization of Lake Ecosystem is crucial to maintain pollution free water quality. The causes to protect the ecosystem for diverse species of the migratory birds were pinpointed [5]. Similarly, it was stated that loss of wet land due to the continuation of present situation [3]. Geologically the Kalar Kahar falls in Salt Range which is famous historically for its exposed unique geology where rocks from early sedimentary deposition to recent are exposed in three important sections known as Khewra Gorge, Road side section of Khewra Choha Saddan Shah and along Motorway (M-2 section). The exposed rocks located in the south of the Lake are primarily composed of sandstone, marl and gypsum which are overlain by limestone. Almost certainly Sakasar Limestone of Eocene age is un-conformably resting over the Salt Range formation. Furthermore, the Salt Range Formation is Pre-Cambrian in age [21]. In the upper horizons of the outcrop, 12-I5 thick alluvium is present at places (Table 1).

MATERIAL AND METHODS

Field reconnaissance surveys were made for collection of data regarding geology, hydrogeology and other related activities affecting the lake and sample points were marked by GIS techniques (Figure I). Recommended procedure [23, 18] was adopted for collection and analyses of water samples. The experimental work is composed of estimation of physical, chemical and biological parameters of the water samples from Lake and feeding springs whereas the samples were tested in Pakistan Council of Scientific Investigation Research, a Government Certified Laboratory. The measurements of these springs were taken through v-notch from 122 to 515 GPM.

Table 1- Physical properties of rock units exposed in the setting of Lake Kalar Kahar

Sr. No	Rock Formation	Physical Properties
1	Gypsum	Gypsum deposits are of two types in the south of lake, in the form of thin seams while at the toe of Ziarat hill, huge deposits are present as big boulders of 5 to 7 feet diameter deposited in the soft matrix of clayey material from where excavations are being made to develop terraces for building construction.
2	Shale	Shale is of different colors, in the south eastern hill slope. It is reddish brown whereas, in the Ziarat Gorge and surrounding area it is dark grey and buff in color.
3	Marl	Due to recent excavation for construction purposes, red blood to maroon and reddish brown marl exposed in the southern hills where it slides during rainfall that is a potential source of sedimentation for lake if not protected without delay.
4	Limestone	Limestone is hard and compact, massive with thick beds. Few exposures are nodular in Zirat Gorge.
5	Sandston	Sandstone in slightly greenish grey color that is spread over large area in the southeast and eastern boundary of the lake. It is medium to course grained, soft and easily erodeable rock. The grain size increases towards the south eastern exposures and degree of cementation is very poor. It is the formation controlling sediments to the lake.
6	Alluvial Deposits	15-20 feet thick alluvial deposits are composed of rounded gravels and boulders of few inches diameters, deposited in clay matrix, mixed with gypsum lumps.

RESULTS AND DISCUSSION

The lake is surrounded by hills making semi-circle in the southern boundary whereas the North and North West of the lake is composed of the alluvial plains, covered with dense population with 1.99 % average growth rate as per 1998 Population Census. Whereas, during 1998, the population of Kalar Kahar was 13,591 persons that presently is appraised at 18,265 persons. Working with arithmetic growth method estimation, in which considering 1998 as base year and growth rate, the projected population will be expected to rise up to 27,087 persons till year 2033 (Figure 2). The water quality of Lake covering an area of 72.7068 m² calculated from the toposheet of Soil Survey of Pakistan is evaluated to understand the capability of surface and ground water for domestic uses (Figure.1). Seventy water samples from fifteen locations were collected each during the month of April 2008, July, 2009 and 2010 respectively (Table 2).

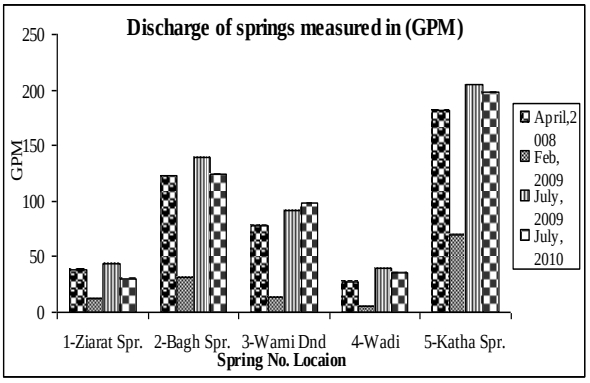

Figure: 2 recharge prospective of feeding springs indicating seasonal variations

Table 2 Assessment of average water quality of the Lake in terms of total dissolved solids (TDS) indicating seasonal effects

Date of measure-ment	No. of Samples	Av. Value of TDS (mg/1)	Remarks
April, 2008	7	613	Sample collected just after spring rainfall
Feb, 2009	5	684	Perennial recharge source is reduced to 26% of average potential
July, 2009	5	602	Due to re monsoon precipitation inflows of the feeding springs increased greatly which caused dilution
July, 2010	4	675	due to heavy rainfall

Various water quality constituents pH, conductivity, total dissolve solids, hardness, alkalinity, potassium, sodium, calcium, chloride, magnesium, sulphate, nitrate, phosphate and fluoride have been determined by adopting World Health Organization standards[14-23], ionic contacts are considered and hydro chemical facies are finalized. Distribution of various constituents indicates that about 12-22% samples over the most permitted perimeter of total dissolve solids, hardness, magnesium, calcium, fluoride and sulphate while 18-28% samples crosses the limit for nitrate. The hydro-chemical data of water samples collected during study tour are presented graphically (Finger 6). The pH values generally are found within the limit of 6.46 to 7.98.The electrical conductivity (EC) and dissolved salts (DS) mainly indicate entire mineral substances of water and could be linked to difficulties of undue hardness, caustic attributes or further mineral adulteration. The conductivity value varies from (672-1054µs/cm) and the maximum conductivity value of 1054 to 1032 µs/cm was observed in sample # 12 and 9 respectively. Intensity of ionized constituent in water is precisely linked with the conductivity measurements besides commonly used to determine the purity of de-mineralized water and total dissolved solids in boiler, cooling tower water, irrigation and domestic supply. Solutions of most inorganic acid, bases and salts are relatively good conductors. It was stated [7] that "In natural water, dissolved solids consists mainly of inorganic salts such as carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of calcium, magnesium, sodium, potassium, iron and small amount of organic matter and dissolved gases" [28]. Current research indicates TDS directly proportion to EC and its values varies from 485 to 732 mg/L. It was realized that water containing more than 500 mg/L of TDS is not considered desirable for drinking water supplies, though more highly mineralized water is also used where water with TDS value is not available [9]. For this reason, 500 mg/L as the desirable limit has been suggested for drinking water. TDS 500mg/L in water instigates inflammation in stomach. In Kalar Kahar area, 35% sample even crosses the maximum permissible limit. Alkalinity in water is mainly associated with the occurrence of carbonates, bicarbonates and hydroxides while bicarbonates are the key procedure on prime constituents of soil. Alkalinity values vary from 112 to 178 mg/L with about 79% samples having alkalinity values within the desirable limit.

Water quality becomes hard impermanent and permanent when magnesium and calcium crossed permissible limits. A perimeter of 300mg/l is suggested a required perimeter while 600 mg/L the extreme acceptable perimeter for drinkable water by World Health Organization (2003). The total hardness standards within study area range from 76 to 427 mg/L (76 to 4276 mg/L). Distribution of hardness values clearly indicates that during pre-monsoon season about 43% samples lies in the appropriate perimeter and 38% within the most acceptable perimeter of water.

Suggested [9] perimeter 75 and 30 mg/L of calcium and magnesium are required for drinking water. Present study shows ground water calcium and magnesium value ranges between 21 - 56 mg/L this indicated a balanced growth of magnesium. Distribution of calcium and magnesium clearly indicates that about 10-20% samples cross the maximum permissible limit of water. Moreover, intensity of sodium fluctuates among 40 to 65 mg/L. Furthermore, it was emphasized that above 50 mg/L of sodium dilution is unacceptable in household practices [6]. While at maximum study locations, sodium intensity is realized higher.

The chloride content ranged from 5 to 270 mg/L. The amount of chloride 250 mg/L is suggested appropriate while 100mg/L the most admissible parameter to potable water. The chloride ion were found in higher concentration in sample number seven, the main reason is the presence of salt-range nearby and heavy rains in spring season. The trends are presented in Figure.5.

Distribution of chloride indicates that more than 80% of the sample remains in the required limits of potable water. It was documented that Sulphate generally occurs as soluble salts of calcium, magnesium and sodium and with time content of water may considerably vary through access of precipitation and recharge of ground water that usually proceed by stationary ponds, puddles and surface overflow stored in lowlands [9]. It is evident from the distribution of sulphate that about 80% samples lies well in necessary perimeter of drinking water while about 10% resists maximum permissible perimeter for drinking water. The nitrate content is found to

vary from 0.48 to 167 mg/L. and amplified concentration at various locations could recognize precisely external removal of sewage and agronomic litters. In general concentration of nitrate was found higher at most of the locations.

Since nitrate is considered a valuable nutrient, rather contaminant but counted for its harmful health hazard. Contamination of noxious metals and their distribution between feed and egg were investigated for their quality, quantity, suitability and possible health hazardous [10, 13]. Advanced concentration of nitrate might initiate a disease recognized as methaemoglobinaemia that usually influence bottle-fed kids, similarly frequent medication by nitrates can be source of carcinogenic diseases [16]. Distribution of nitrate indicates that about 61% samples have depicted nitrate content less than 45mg/L. It was advocated that higher nitrate concentration may be attributed due to combined effect of contamination from domestic sewage and runoff from fertilized fields [2]. The fluoride concentration varies from nil to 5.48 mg/L. The fluoride concentration beyond permissible limit of 1.5 mg/L is observed in about 15% samples. Fluorides are present in soil strata due to natural geological formations in the form of fluorspar, fluorapatite, and amphiboles such as hornblinde, trimolite and mica. Weathering of alkali, silicate, igneous and sedimentary rocks especially shale contributes a major portion of fluorides to natural waters. The accumulation of fluoride in soil strata eventually results in its leaching due to percolating water pressure resulting increase fluoride concentration in ground water.

The area is located in semi-arid zone which receives about 30” mean annual rainfal1 during a year. The monitoring and estimation of the spring inflows from April 2008 to July 20 10 shows that all the springs feeding to the Lake can be classified as perennial springs however, their discharge varies greatly during the year. Our measurements of these springs through v-notch from 122 to 515 GPM have confirmed the monsoon recharge. Three consecutive years’ data of feeding springs was gathered that indicates seasonal variations in recharge prospective (Figure 3)

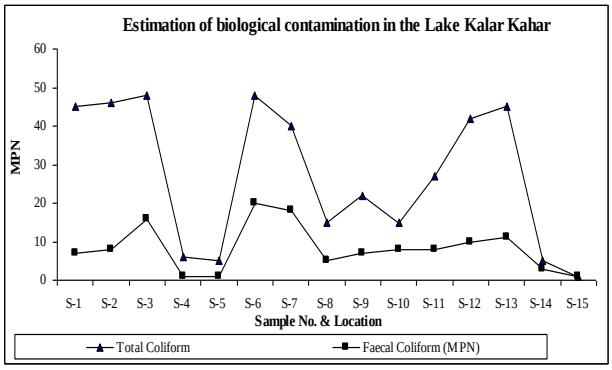

Figure: 3 Quantitative determination of pathogens in the Lake Kalar Kahar and its feeding springs

The lake water is physically highly contaminated while principal sources of physical contaminations are municipal waste generated by tourists who directly disposed of during boating and high rate of segmentation caused by excavation along the slops on the nearby hills. Severe types of microbiological contamination have been recorded (Figure 4).

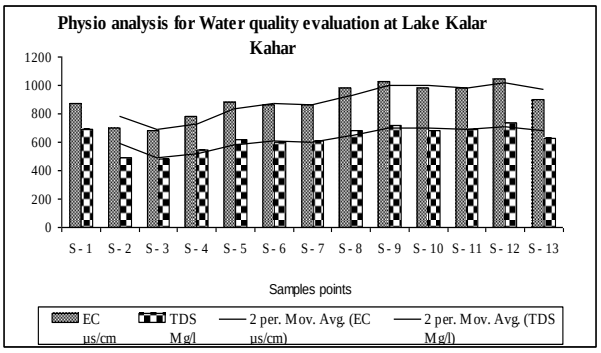

Figure: 4 Graphic presentation of Physio-Chemical results of selected water sample

The results of water sample tested for coliform and faecal coliform indicated that lake and feeding springs are contaminated and sewage contamination has been confirmed. Due to sewage contamination and disposal of physical waste, unwanted algal growth causing the blockage of sun light which is affecting the aquatic life of the wetland. It was suggested that eutrophication is outcome of undue growth of plant by the amplified accessibility of added preventive development factors i.e. carbon dioxide, sunlight and nutrient fertilizers required for photosynthesis [20]. The results for chemical analysis of water samples from Lake presented (Figure 5) illustrated that, all the samples have crossed recommended limits [23, 18] in terms of total dissolved solids.

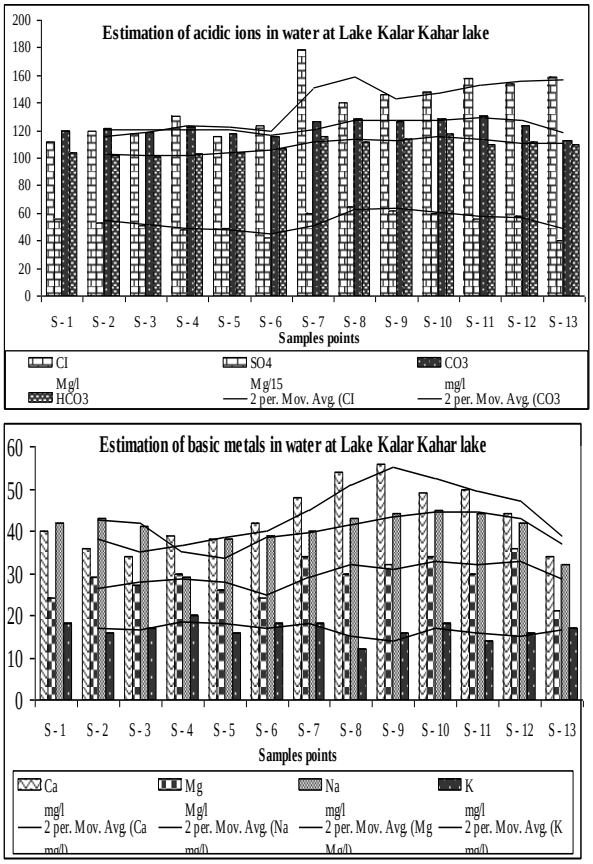

Figure: 5 shows sodic ion and basic metals along with their trends

The periodically monitoring of the lake water shows that there is large variation in chemical quality and which is predominantly controlled by the dilution process of monsoon and other precipitation. Our findings are in line with the results reported by scientists [7, 19]. Sequential monitoring of the lake water has indicated a great variation in chemical quality of water that is primarily controlled through the monsoonal and other precipitation dilution processes as showed in figure 4. Principal sources of physical contamination are municipal waste generated by tourists which are mostly directly disposed of in the lake during boating and high rate of sedimentation caused by excavations along nearby slopes.

DISCUSSION

This study indicates that Lake is in under sever threat of environmental degradations due to urbanization and mining in the catchments areas of the lake as physical and biologically high level contamination has occurred. Eutrophication evaluated by [1] and established a leading cause of impairment of many freshwater and coastal marine ecosystems in the world. The chemical quality of the lake is predominantly controlled by monsoon precipitation which greatly dilutes its total dissolved solids considerably. SwaIik Group's soft greenish grey sandstones are exposed in the east of the lake. Recently large scale excavations have been made in SwaIik Group's formations to create level land for construction of housing scheme and commercial bui1dins in the surrounding of the lake that have exaggerated weathering and erosion in many folds. One of major cause of storage reduction is increase in population during the last decade in the area. Until now there is no municipal based regular water supply system in the town of Kalar Kahar. Hence, the local community at the boundary of the lake is pumping water for their daily requirements through shallow pumps installing at the depth of 10′-14'. As a. result of over pumping induced depletion has started from the lake which may cause eutrophication and damage ecosystem of the lake permanently. It was also highlighted that eutrophication may occur naturally but can also be the result of human activity (cultural eutrophication from fertilizer runoff and sewage discharge) and is particularly evident in slow-moving rivers and shallow lakes [11]. It is suggested that there should be a complete ban on the tourists to take food items with them during boating which are mostly thrown in the lake and caused physical contamination. In the watershed area especially in the nearby loping hills large scale plantation should carried out to increase recharge of the lake feeding springs. Encroachments of the lake should be stopped and materialize restoration of the original regime of the lake, this will help in improvement of the biological quality of the lake. The water of the feeding springs should be rerouted to develop hills which will increase oxygen to control eutrophication and related conditions through aeration. To find out the changes in the water contamination of the lake long term monitoring is recommended which will help to propose remedial measures. It has been scrutinized that projected climate change and augmented population retain probability to promote degradation in water quality as well as quantity [17]. Capacity building of water resource managers to curtail the concentration and occurrence of algal and cyanobacteria blooms is highly desirable.

CONCLUSION

Due to accelerated environmental deterioration, fresh water resources are under great threat throughout the globe. Clean Water and Safe Drinking Water Acts in the 1970s took significant steps to reduced fortification of nutrient in water quality. However, cultural eutrophication and concomitant harmful algal blooms continue to be the leading cause of water pollution for many freshwater and coastal marine ecosystems and are a rapidly growing problem in the developing world [22]. Conservation and watershed management to revitalize the shrinking water resources needs dynamic efforts. It was predicted that water quality and quantity will further reduce due to climate change, pollution and species invasions [20]. To minimize the cultural eutrophication and restoration of aquatic resources a shared vision but integrated approach by the scientists, policy makers and stake holders/communities is the dire need for reduction of nutrient feedback via developing sustainable bio-manipulation techniques.

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