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HABITATS OF *Lutrogale perspicillata* IN THE NARAYANI RIVER, CHITWAN NATIONAL PARK, NEPAL: ASSESSMENT OF WATER QUALITY

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ABSTRACT

Analysis of water quality in the otter habitats of the Narayani River was conducted during the month of June, 2012 in order to assess the health of aquatic ecosystem. The analysis of water from 12 sampling stations including an industrial site in Sikrauli estimated the values of parameters in mg/L such as chloride, ammonia, nitrate, orthophosphate, dissolved oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD) at 5.3 ± 3.4; 0.13 ± 0.07; 1.23 ± 0.12; 0.06 ± 0.04; 7.3 ± 0.5; 7.5 ± 4.6; and 21.7 ± 10.4 respectively.

Similarly, water sample from industrial area in Sikrauli was also analyzed for heavy metal concentration. The presence of heavy metals such as mercury, lead, arsenic and cadmium was not detected. But, chromium, iron and manganese showed the concentration of 0.02, 10.5 and 0.2 mg/l, respectively. All the water quality parameters assessed were below the threshold level prescribed by the Nepal Government and therefore, we concluded the water in the study area in healthy condition. This study stresses the need of periodic water quality assessment and monitoring of otter habitats to ensure the healthy wetlands for the conservation of aquatic species in the river basins of Nepal.

Keywords: Ammonia, nitrate, dissolved oxygen, heavy metals, Narayani River, otter habitats, water quality.

INTRODUCTION

The otters are mammals of the Mustelidae family which are carnivorous in habit. They are semi-aquatic dwelling in wetland habitats such as rivers, marshes and lakes. The foods of otters are amphibians, fish and crustaceans with seasonal variations. The otters are top predators and important biological indicator of the health of rivers and wetlands. There are 5 species of otter in Asia, namely 1) Eurasian otter, 2) Smooth coated otter, 3) Hairy nose otter, 4) Small clawed otter, and 5) Sea otter. Of these only 2 species are recorded in Nepal: 1) Eurasian otter, *Lutra lutra; and* 2) Smooth-coated otter, *Lutrogale perscipillata*.

The smooth coated otter essentially is a lowland species. Generally, they use large rivers and lakes, peat swamp forest, mangrove forest along the coast and estuaries, and in South-East Asia,they even use rice fields for foraging. The smooth coated otter, *Lutrogale perscipillata* is included in Vulnerable (VU) category by IUCN and in the Appendix II of CITES. The *Lutrogale perscipillata* is one of the least studied species though both species found in Nepal are being protected by Aquatic Life Protection Act, 2002. However, the Nepal government still has not included this species in the protected list despite their population being in the declining trend and only restricted to fragmented small populations in the major river basins.

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In Nepal, the otter population are severely threatened by increasing human disturbances – overfishing, poisoning, industrial pollution, reduction in prey biomass, grazing, sand and boulder extraction and construction of large hydro-electric dams (*Acharya and Rimal*, 2007;*Acahrya* and *Lamsal*, 2010; *Acharya et al*., 2010; *Acharya and Rajbhandari*, 2012; *Rajbhandari* and *Acharya*, 2013).

The increasing industrialization and intensification of agriculture in Nepal is increasing the pollution load in the rivers while in the absence of government measures, the pollution load will continue to increase. Discharge of untreated industrial effluents, domestic waste-water, and mineral rich agricultural runoff into the water bodies is common in Nepal. This has enhanced pollution, eutrophication and excessive growth of weeds, particularly alien species such as water hyacinth thereby resulting in decreased species diversity and loss of function, e.g. potable water supply (*IUCN*, 2002).

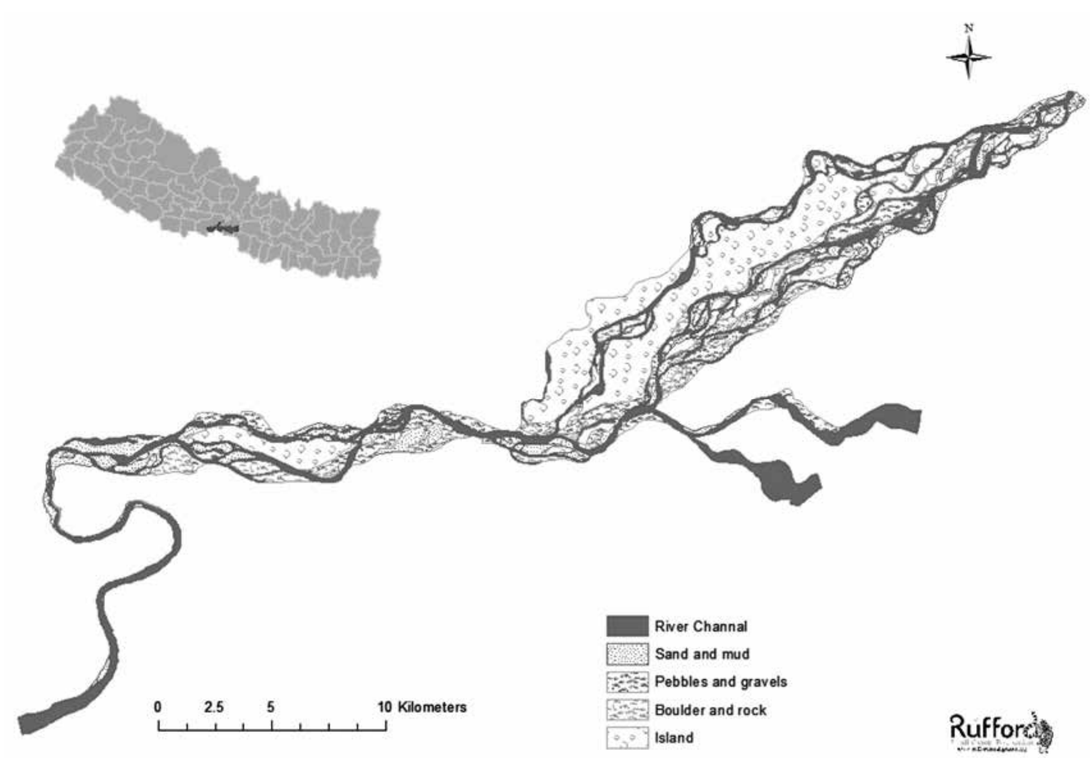
Very few studies have been undertaken focused on the effects of industrial pollution on aquatic life such as *gharial*, otter and dolphin. *Sharma et al.* in 2007 reviewed the water quality studies in the rivers of Nepal, but this review does not cover the effects of agricultural and industrial pollution on aquatic fauna. However, some studies (*Sah et al.*, 2002) indicated that industrial pollution from the paper pulp industry had adverse effect on the fish diversity.

Some recent studies by *Bhattarai and Acharya* (2007) and *Diwaker et al.* (2009) determined the water quality of Beeshazar Lake Complex and Ghodaghodi lake complex (Ramsar sites in Nepal).This paper deals with the preliminary study on the status of water quality in the otter habitats of the Narayani River.

STUDY AREA

The study was carried out in Narayani river of the Chitwan National park (CNP) (27^o 34' to 27 ^{o} 68' N and 83 ^{o} 87' to 84 ^{o} 74' E) in Nepal, a UNESCO World Heritage Site from April 2011 to March 2012 (Figure.1). This park is one of the largest (932 km^2) remaining natural lowland forest communities in the outer foothills of the Himalayas.

Figure 1: Narayani River within CNP



The regional climate is sub-tropical monsoon, with an average yearly precipitation of 230 cm; 90% occurring during May-September. Chitwan's vegetation has been influenced by major river systems with exception of human-related disturbances. The Narayani and the Rapti rivers have markedly influenced the soils of the valley, almost eliminating the original basin deposits (*Carson et a.l*, 1988).

The CNP is characterized by tropical to sub-tropical forest where Sal forest (*Shorea robusta*) is considered "climatic" climax which covers about 70% of the park *(Bolton,* 1975). The deciduous riverine forest constitutes about 7% of the park (Bolton, 1975) with early succeeding species like *Bombax ceiba* and *Trewia nudiflora* with *Ephretia laevis*, *Litsea monopetala* and *Premna obtusifolia* (*Lehmkuhl*, 1983). The grassland makes up about 23% of the park (Bolton, 1975) and form a diverse and complex community over 50 species. The boulders (wetlands and rivers) constitute about 10.9% and Khair and Sisso cover 4.6% of the park.

The park with its pristine ecosystem is one of the best protected areas in South Asia harboring many large mammals such as one-horned rhinoceros, Bengal tiger, gaur, wild elephant, leopard, four species of deer, gangetic dolphin and the smooth coated otter. In addition, the other aquatic fauna of the rivers include gharial and mugger crocodiles, 4 species of turtle, over 170 species of wetland birds and 113 species of fish.

METHODOLOGY

Water sampling and processing of water samples

Water samples were collected from 12 key otter habitats to determine the degree of pollution and its possible consequences on otter habitat and population. Important water quality variables such as dissolved oxygen, B.O.D., C.O.D., temperature, total phosphates, nitrates, turbidity, total solids, were measured. During the sample collection, the mouth of the sampling bottle was directed against the water current. The samples were kept cool in an icebox during the transport period. Samples for physico-chemical parameters were collected in one liter capacity clean polyethene bottles. Samples for toxic metals and iron and manganese analysis were collected in 500 ml polyethene bottles and were preserved with concentrated nitric acid. Most of the parameters were analyzed on the same day of sample collection. The samples were preserved according to the standard norms for analyzing other parameters.

For DO, the samples were collected in BOD bottles and DO was fixed with 2 ml of manganous sulphate and alkali iodide azide. DO was measured by using Winkler's modified method (iodometric titration). For BOD, two BOD bottles were used for each sample. First bottle was filled and directly incubated at 20°C for five days and the second bottle was preserved for initial DO analysis. After completion of incubation, the final DO was measured for the second bottle. The difference between initial and final DO was calculated as BOD.

The pH and electrical conductivity were measured by WTW electrodes. COD was analyzed by titration with ferrous ammonium sulfate after dichromate digestion of the sample. Chloride was determined by argentometric titration (titration with silver nitrate). Concentrations of ammonia nitrate and orthophosphate and turbidity were measured by spectrophotometric method. Total suspended solid was determined by gravimetric method.

Physico-chemical analysis of water

All the Physico-chemical parameters (except total nitrogen) were determined according to the methods described in APHA, AWWA, WEF (1988). The important physico-chemical characteristics of water samples from 12 locations in between Sikrauli to Bhosarghat of western branch of the Narayani River along the Nawalparasi district were determined with the objective of assessing the status of river water quality for the protection of key aquatic species of river basin including otters. All these samples are from key otter bearing areas as identified during June 2012.

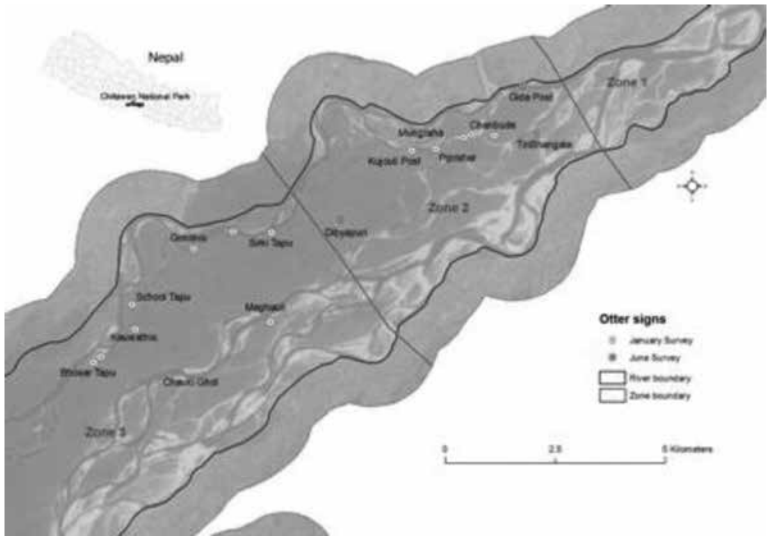
The heavy metals such as Chromium, Mercury, Lead, Arsenic, Cadmium, Iron, and Manganese were determined by Atomic Absorption Spectrometer (ASS).

RESULTS AND DISCUSSION

Distribution of otter habitats

A survey conducted in January 2008 and June 2008 from Gidda to Bhosarghat on the western channel of the Narayani River identified key otter habitats (Figure 2).

Figure 2: Distribution of otter signs in Narayani River



Physico-chemical parameters analysis

The physico-chemical parameters are considered as the most important principles in the identification of the nature, quality and type of the water for any aquatic system. The physico-chemical analysis of water with mean and standard deviation is shown in Table 1.

Table 1: Physico-chemical characteristics of water with mean and standard deviation

Parameters	Unit	Value
Temperature	^{o}C	24.8 ± 0.4
pH		8.1 ± 0.2
Electrical conductivity	µS/cm	211.3 ± 6.0
Turbidity	NTU	60.7 ± 31.4
Total suspended solid	mg/L	193.3 ± 76.1
Chloride	mg/L	5.3 ± 3.4
Ammonia	mg/L	0.13 ± 0.07
Nitrate	mg/L	1.23 ± 0.12
Orthophosphate	mg/L	0.06 ± 0.04
Dissolved oxygen	mg/L	7.3 ± 0.5
Biochemical oxygen demand (BOD_5)	mg/L	7.5 ± 4.6
Chemical oxygen demand (COD)	mg/L	21.7 ± 10.4

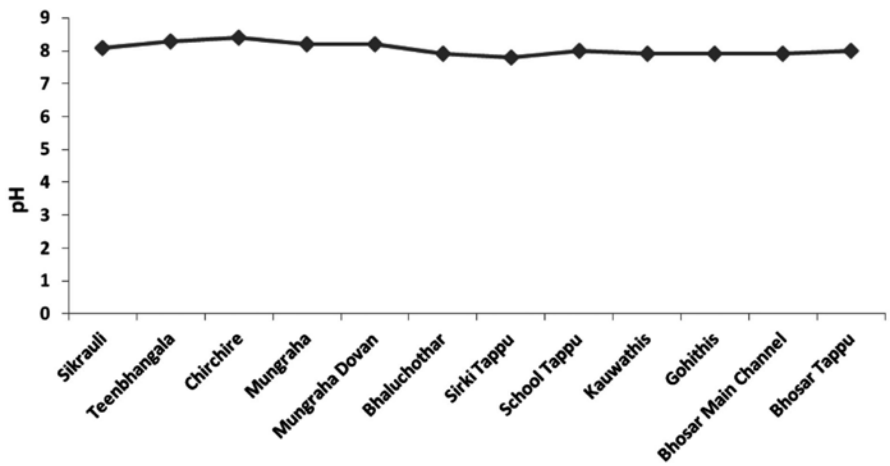
TURBIDITY

The mean value of turbidity was 59.83 with the standard deviation (±) 29.23. The maximum value of turbidity was found to be 92.0 NTU and the minimum value was 24.0 NTU. All the values of turbidity observed exceeded the Nepalese aquaculture standard of 25 NTU. High turbidity values could be due to suspended matter contributed by run off from the catchment area.

pH

The mean value of pH was 8.05 with the standard deviation (±) 0.1803. The maximum pH was found to be 8.3 and the minimum value was 7.9. All the pH values are within the aquaculture standards of 6.5-9.9. Although pH may not have direct effect, high pH values favor gaseous form of ammonia which is more toxic than ammonium to fishes (Figure 3).

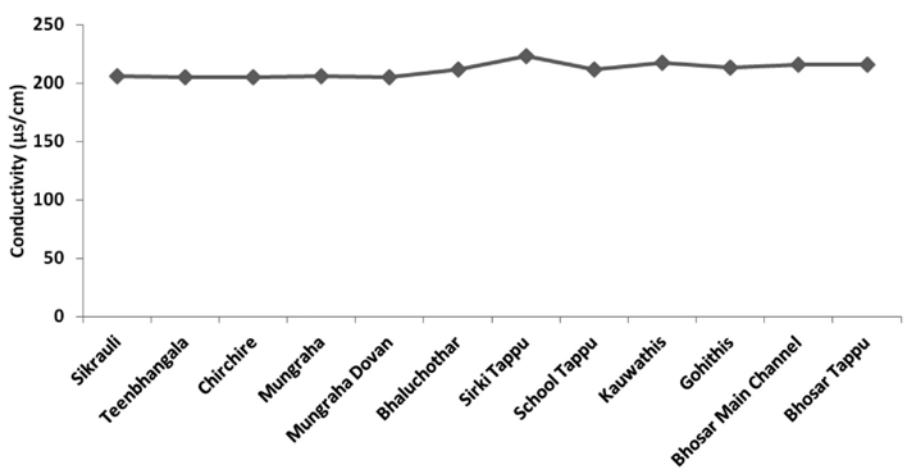
Figure 3: pH values of sampled sites



Electrical Conductivity

The mean value of electrical conductivity was 211.33 with the standard deviation (±) 5.7203. The maximum value was 223 μs/cm and the minimum value was 205 μs/cm. Usually, unpolluted water has low conductivity, below 100 μs/cm^2. Highest conductivity value of 223 μs/cm was observed in Sirki Tappu. It could be contributed by natural runoff from grassland and forest areas (Figure 4).

Figure 4: Conductivity values of sampled sites



Chloride

The mean value of chloride was 5.417 with the standard deviation (±) 3.2005. The maximum value of chloride was found to be 14.0 mg/L and the minimum value was 1.0 mg/L. Usually high concentration of chloride together with high ammonia indicates sewage pollution. All the chloride values were well below the standard value of 600 mg/L. Low values of chloride together with low values of ammonia suggest it is less likely that the water is contaminated with sewage.

Ammonia

The mean value of ammonia was 0.133 with the standard deviation (±) 0.0624. The maximum value was found to be 0.2 mg/L and the minimum value was 0.1 mg/L. The higher levels of ammonia content in surface water are likely due to contamination from domestic sewage or agricultural runoff. Ammonia is particularly harmful to fish even in low concentrations. Alkaline pH favors presence of gaseous ammonia, below pH 7.

The aquaculture standard of ammonia is 0.025 mg/L. All the values of ammonia observed exceeded the standard. Therefore, water may not be as suitable for aquaculture as far as the concentration of ammonia is concerned. However, different species of fishes may be susceptible to different concentrations of ammonia. Molecular ammonia is toxic and ammonium is not. Gaseous ammonia (molecular ammonia) above 0.2 mg/L can cause death of several species of fish.

According to *Chapman* (1996), NH_3-N concentration in unpolluted waters should normally be <0.1 mg L^{-1}, but that it might occasionally reach 0.2 mg L^{-1}. Concentrations higher than this value suggest organic pollution from sources, such as domestic sewage, industrial wastes and fertilizer run-off.

A study carried out by *Hassan et al* (2005) in El-Kabir River found the value of ammonia-nitrogen concentration exceeding the 0.1 mg L^{-1}, averaging 0.27 mg L^{-1}, with the highest individual concentration equal to 2.54 mg L^{-1}.

Nitrate

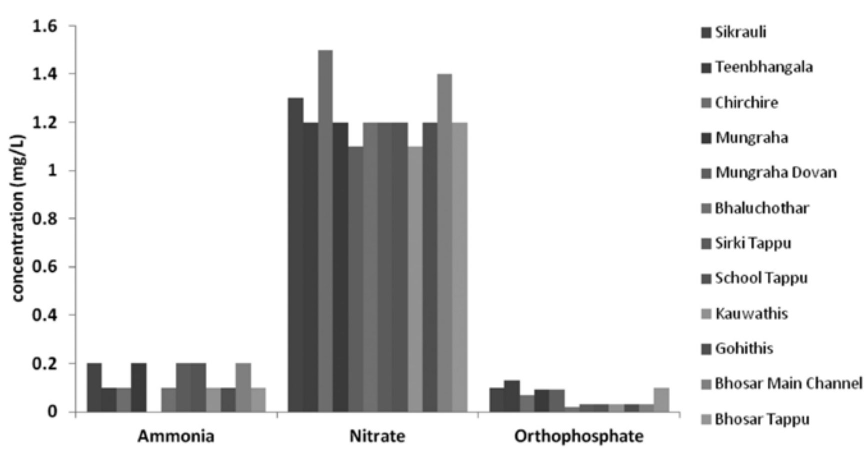
The mean value of nitrate was 1.233 with the standard deviation (±) 0.1106. The maximum value was found to be 1.5 mg/L and the minimum value was 1.1 mg/L. Nitrate can come directly from fertilizer application or from biological oxidation of ammonia. Nitrite is unstable and is readily converted to nitrate or ammonia. Fertilizer use in agriculture and domestic sewage are the main sources of nitrate contamination. Nitrate concentrations are also fairly low and meet the standard in all the sampling stations. It seems there is no risk from the existing nitrate concentrations.

Nitrate-nitrogen is the most common form of N in fresh water, seldom exceeding a concentration of 0.1 mg L^{-1}. Hassan et al. (2005) in El-Kabir River also found the mean value of nitrate-nitrogen as 1.23 mg L^{-1}. This concentration might be enhanced by municipal and industrial waste waters, leachates from waste disposal,sanitary landfills, and from fertilizers. Human influences can increase the concentration to 1.0-5.0 mg L^{-1}. Values >5.0mg L^{-1} usually indicate pollution by human and animal wastes (*Chapman*, 1996).

Phosphate

The mean value of orthophosphate was 0.0625 with the standard deviation (±) 0.0365. The maximum value was found to be 0.13 mg/L and the minimum value was 0.03 mg/L. Phosphate itself may not pose direct threat to health but it can enhance eutrophication which can deplete dissolved oxygen and hinder light penetration in water bodies. Values of phosphate are well below the standard value of 0.6 mg/L in all the 12 sampled stations (Figure 5).

Figure 5: Concentration values of ammonia, nitrate and orthophosphate



Phosphorus is usually present in natural waters as phosphate. It is a plant nutrient needed for growth, and a fundamental element in the metabolic reactions of plants and animals. Plant growth is limited by the amount of phosphorus available. In most water bodies, phosphorus functions as a "growth-limiting" factor because it is usually present in very low concentrations. Phosphorus stimulates the growth of rooted aquatic vegetation. These plants, in turn, draw phosphorus previously locked within bottom sediments and release it into the water, causing further eutrophication.

Dissolved oxygen (DO)

The mean value of DO was 7.258 with the standard deviation (±) 0.444. The maximum value was found to be 8.0 mg/L and the minimum value was 6.4 mg/L. Concentration of DO in water is influenced by temperature, dissolved salts and turbulence. Low temperature, low dissolved salts and turbulence increase DO in water. Fish normally requires 5 mg/L although some can live below this value. Organic pollution tends to decrease DO level. The DO values in all the stations were above the minimum required limit of 5 mg/L.

DO is essential for the maintenance of healthy lakes and rivers. The presence of oxygen in water is a positive sign, the absence of oxygen is a signal of severe pollution. Rivers range from high to very low levels of DO- so low, in some cases that they are practically devoid of aquatic life. Waters of consistently high DO are usually considered healthy and stable ecosystems capable of supporting many different kinds of aquatic organisms (*Mitchell & Stapp*, 1996).

Biochemical oxygen demand (BOD)

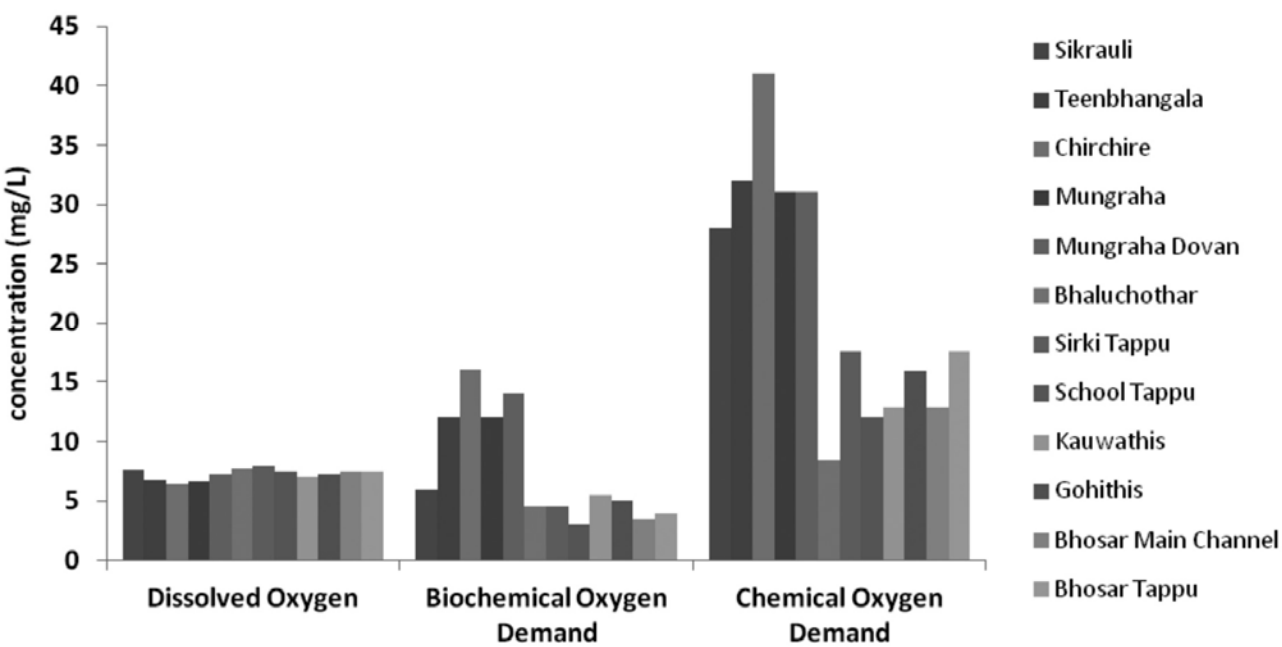
The mean value of biochemical oxygen demand was 7.5 with the standard deviation (±) 4.4159. The maximum value was found to be 16.0 mg/L and the minimum value was 3.0 mg/L. Except in the station Chirchire where the BOD values was 16 mg/L, all the other stations meet the standard value of 15 mg/L.

In rivers with high BOD levels, much of the available DO is consumed by aerobic bacteria, robbing other aquatic organisms of the oxygen they need to live. Organisms that are more tolerant of lower DO may appear and become numerous, such as carp, midge- larvae, and sewage worms. Organisms that are intolerant of low oxygen level, such as caddis fly larvae, mayfly nymphs, and stonefly nymphs, will not survive (*Mitchell & Stapp,* 1996).

Chemical oxygen demand (COD)

The mean value of chemical oxygen demand was 20.93 with the standard deviation (±) 10.5494. The maximum value was found to be 41.0 mg/L and the minimum value was 8.4 mg/L. COD is used to indicate pollution strength of both sewage and industrial effluent. The COD values are also within the standard COD value of 40 mg/L except at the stations Sikrauli and Chirchire (Figure 6).

Figure 6: Concentration values of DO, BOD and COD



Temperature

The mean value of temperature was 24.83 with the standard deviation (±) 0.3727. The maximum value was found to be 25°C and the minimum value was 24°C.

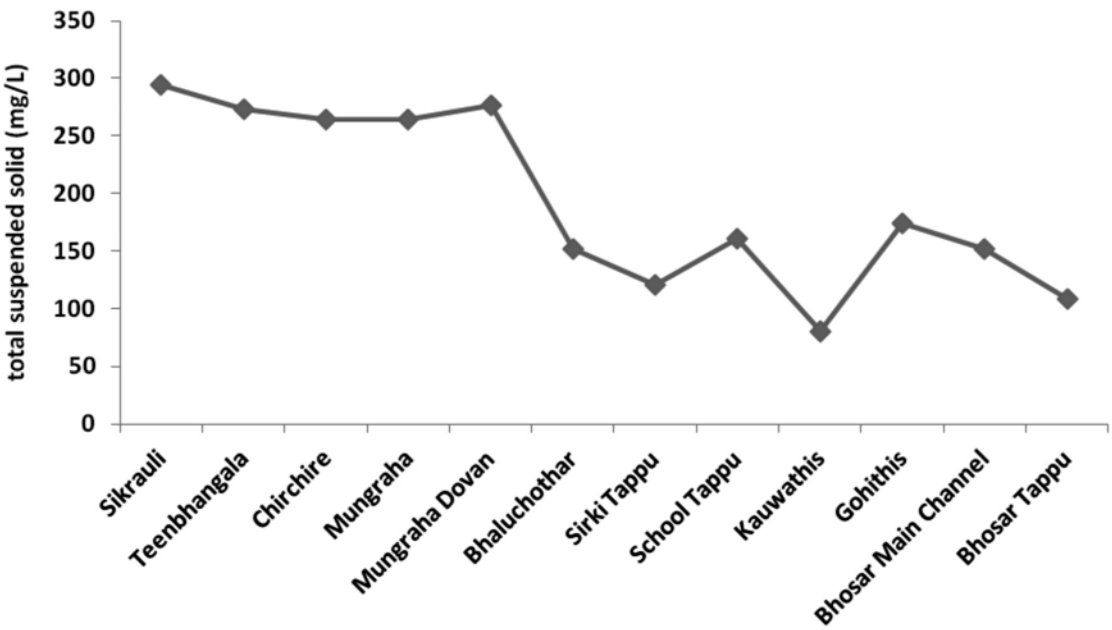
Carbon dioxide

The mean value of carbon dioxide was 4.583 with the standard deviation (±) 0.8620. The maximum value was found to be 6 mg/L and the minimum value was 3 mg/L.

Total suspended solids

The mean value of total suspended solid was 194.75 with the standard deviation (±) 72.1816. The maximum value was found to be 277 mg/L and the minimum value was 80 mg/L (Figure 7).

Figure 7: Total suspended solids in the sampled sites



Heavy metals

Water samples from Sikrauli, which is an industrial area were taken for analyzing the heavy metals and its impacts on the aquatic life. Iron is dissolved as ferrous iron in anaerobic groundwater. Upon contact with air it precipitates as ferric iron. Therefore, in surface water because of oxidation, iron is normally not detected in appreciable concentration. Usually, manganese is found in lower concentration than iron. Iron and manganese can cause blackening of surfaces. Fish seems to be susceptible to iron and manganese content in water. The aquaculture standards for iron and manganese are 0.01 mg/L and 0.1 mg/L respectively. Iron and manganese measured in Sikrauli station exceeded the limit (Table 2).

Table 2: Heavy metal concentrations of water in Sikrauli

S No.	Parameters	Mg/L
1	Chromium	0.02
2	Mercury	< 0.005
3	Lead	< 0.01
4	Arsenic	< 0.005
5	Cadmium	< 0.003
6	Iron	10.5
7	Manganese	0.2

The presence of heavy metals such as mercury, lead, arsenic and cadmium is not detected. But, chromium, iron and manganese show the concentration of 0.02, 10.5 and 0.2 mg/L, respectively.*Sah et al.* (2002) reported that heavy metals such as Fe, Cu, Pb, Zn, Mn and B present in effluents from paper and pulp were not above the threshold value in fish collected from polluted site (Gaidakot). There is a need to carry out a detailed investigation of impacts of industrial pollution on the key indicator species of river basins (*Acharya & Rajbhandari,* 2012; *Rajbhandari & Acharya,* 2013). *Sah et al* .(2002) estimated Pb content in paper and pulp effluents between 0.01 and 0.28 mg/l. In Narayani River, the average content of Pb in water was from 0.013 to 0.04 mg/l which was higher at the mixing zone (*Sah et al.*, 2000).

This study estimated the value of Pb in Sikrauli near the industrial area as less than 0.01. Other heavy metals such as Chromium, Mercury, Arsenic, Cadmium, Iron and Manganese were below the threshold level.All the water quality parameters analyzed in the study were below the threshold values. In river Narayani, otters occurred in densely covered, sandy islands between shallow low-water channels, unpolluted, with less human disturbances. Otter distribution agreed with reported otter preference in medium-sized fluvial habitats, with high backside vegetation cover, unpolluted, with low or very low human disturbance and surrounded by forests (*Prenda et al*., 2001)

CONCLUSION

The water quality analysis conducted in 12 sampling stations within otter habitats in CNP showed normal values. Therefore, there is no evidence of industrial pollution in the area. However, detailed investigation and seasonal monitoring of water quality is required to understand the health and functions of the ecosystem. The impact of pollutants on aquatic life is less known in the river systems of Nepal. Hence, the protected areas should be on priority in designing water quality monitoring protocols and same ought to be implemented effectively in the area to strengthen the aquatic life conservation.

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