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Research Article

DISTRIBUTION AND HABITAT STATUS OF GANGES RIVER DOLPHIN *(Platanista gangetica)* IN MOHANA RIVER SEGMENT OF WESTERN NEPAL

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ABSTRACT

An endangered species of Ganges River dolphin (*Platanista gangetica*) in Mohana River and its population status was reported employing synchronized point count. The physicochemical parameters of water were determined using pseudo-random water sampling along various segments of the river. Mean sighting rate during monsoon, 2018 and pre-monsoon, 2016 were one dolphin per 1.355 km and 1.65 km, respectively, with a clumped distribution. Physico-chemical parameters test showed that Mohana River was slightly alkaline with high turbidity and low vulnerability to an acid deposition with a high amount of total phosphorous, indicating a high eutrophication productivity range for both seasons. Water quality is not significantly different during the study period, and the aquatic parameter showed that agricultural activities along the river may have an influence on water quality.

Keyword: *Platanista gangetica*, Mohana River, Karnali River, Nepal

INTRODUCTION

Water quality is crucial for the survival of aquatic species. Poor quality can lead to a decrease in productivity of the aquatic ecosystem, and loss of aquatic biodiversity. In addition, human activities can further worsen the condition. Freshwater system is subjected to various types and level of nutrients, sediments, and pollutants drained from agricultural fertilized fields and urban areas. Hence, it is imperative to maintain a healthy aquatic environment where endangered species inhabit. For this reason and the importance of freshwater as a human resource, studies are focused on evaluating or checking river "health," "status," or "condition" (Bailey *et al.*, 2004).

Distribution of aquatic species is related to water quality, e.g., various aquatic parameters had an influence on fish species distribution in the North branch of Moose River basin (Schofield & Driscoll, 1987). Rashleigh *et al.* (2009) showed a relationship of fish and shellfish distribution to water quality. Hence, water quality can also impact the distribution of aquatic life forms, other than fishes, such as Ganges River dolphin (*Platanista gangetica)*, locally referred to as "Sous" or sometimes "Susu". They are found in Nepal, India, and Bangladesh, and distributed throughout the freshwater river network of Ganges-Brahmaputra-Megna and Karnaphuli (Anderson, 1878). The species of river dolphin are listed as endangered and protected by country through the Wildlife Act of 1973 (DNPWC, 1973). They have been facing a severe threat from human-related activities and habitat degradation with a severely fragmented population (IUCN, 2019). The species is seasonally recorded upstream in Nepal during the wet season, i.e. July-September. Reeves and Brownell (1989) reported that dolphins leave the feeder river and flock together downstream in the main river channel from October to April. They inhabit flooded lowlands and flooded channels beside the main river channel (Jefferson *et. al*., 1993).

Further, distribution can be restricted by the lack of water and the presence of rocky barriers (Reyes, 1991). Sinha *et. al*. (2000) reported that part of population had been extirpated in Gandak River segment in Nepal, i.e., above the Gandak barrage and Sarda River above the upper and lower Sarda barrages in India. Dolphin has been reduced to insignificant numbers in Koshi River segment, i.e., above the Koshi barrage (Smith *et. al.*, 1994). Another population has been seasonally observed in Karnali River segment and Mohana River within Nepal (Chalise, 2016a). But information related to water quality has been missing from several of the previous studies as well as from the habitat where existing population of dolphins inhabit.

Habitat fragmentation, change in depth of water, increased sedimentation, and reduced flow (Leatherwood & Reeves 1994) have created challenges for conservation of dolphin. Besides, other conservation issues impacting status of dolphin are less river depth (Baruah *et al*., 2012), catch in gill nets (Biswas & Boruah, 2000; Choudhury *et al*., 2012), hunting the species for oil (Smith *et al.*, 2009), pollution of the rivers from polychlorinated biphenyls (PCBs) and dichloro-diphenyl trichloro-ethane (DDT) (Kannan *et al.*, 1997, 2005), and overfishing (Kelkar *et al*., 2010-). Since, the early days of studies on dolphin and river habitat (Shrestha, 1989), the land use pattern in area adjoining habitat have shifted because of an increase in urbanization (Bakrania, 2015) (i.e., Increase in human settlement, dependence on chemical fertilizer for farming, increase in anthropogenic/commercial activities upstream). Hence, the lack of information on the aquatic parameter influenced by human activities can impede conservation plans and projects. Therefore, the present work aimed at investigating the distribution pattern and physicochemical parameter of Mohana River. Although few studies were performed on different biological aspects, none of them have explored the state of river quality which is essential not only for dolphins but other aquatic fauna on which dolphin depends.

MATERIALS AND METHODS

Study sites

A population census was performed in two different years (2016 and 2018) at Thapapur, Baidi, Tikapur Municipality (Fig. 1) in Kailali district (28.44° N, 80.99° E) which is located in the Western part of Nepal. The study site constitute of different river segments such as Mohana River, Kandra River, Kada River, Kulariya River, Pathariya River and Karnali River (Chalise, 2016 b). Census for pre-monsoon period was reported from 15-25 July 2018. In pre-monsoon, 79.3 km of river segment was surveyed whereas census for monsoon was published from 10-20 July 2016. Total 81.3 km was surveyed in the monsoon period. Water sampling for physicochemical analysis was carried in 2018 (for pre-monsoon period and monsoon period).

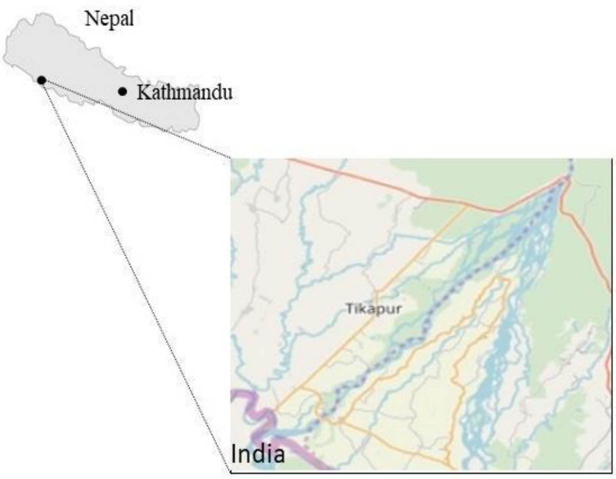


Fig. 1. Study site of Karnali river (flowing North-South) and Mohana River (flowing West-East)

Survey and data collection

The data was collected, for the census, from early morning 7:00 am - 11:00 am. Sixteen observation spots were selected during the monsoon period in 2016, and 35 observation spots in 2018 (pre-monsoon period) using ad hoc sampling. These spots were confirmed through local consultations, initial field observations and preliminary surveys. Each observation spot had three observers in accordance with Smith & Reeves (2000), for accurate estimation and every census count was performed synchronously using 7x binocular and rangefinder at 7:00 am for one minute and each observation count was repeated every fifteen minutes at the same time in all the points to reduce repetition of the count. Based on sighted dolphin individual, total maximum point count was estimated for each river segment. Surveys did not extend into India since the Mohana River traverse between Nepal-India borderline, conducting line transect was complicated due to security concerns. The river segment in this study is not wider as compared to previous studies that used line transects (Vidal *et. al*., 1997).

Physico-chemical parameters analysis

Based on reports of sighting (information collected from local individuals), water was sampled out in each major confluence, and in between confluences. Eight sample spots labeled as 1-8 were sampled in both pre-monsoon (15-25 July 2018) and monsoon (23 August-3 September 2018) periods (Fig. 2). These spots were selected based on various confluence points since mixing of the river adds more components downstream. Based on that, other different stations were set between two confluences. Spot 1, 3, 6, 7 were confluences and 2, 4, 5 were in between confluences and spot 8 was the extreme upper point (i.e., above Karnali bridge) where dolphin had never been sighted before. Spot 8 lies about 1.5 km upstream from the area dolphin was lastly reported.

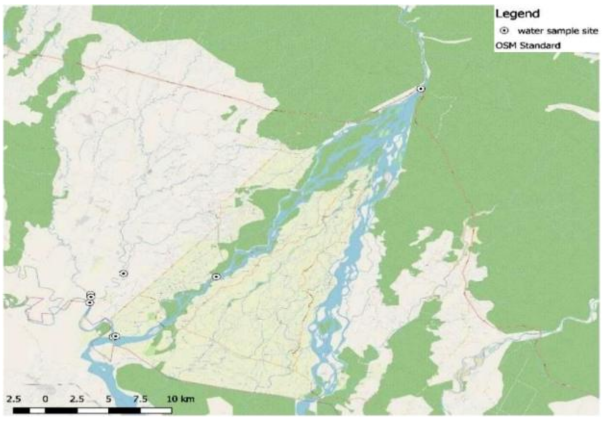


Fig. 2. Water sampling sites in Ganges River dolphin habitat

It was selected to receive a reference index which could inform us the difference in habitat quality in relation to the presence and absence of dolphins. Tiwari (2015) discussed the need for testing different parameters of water quality which led us to select parameters for testing water quality. The physicochemical parameter tested in the present study were pH, electrical conductivity, turbidity, total suspended solids, total dissolved solids, ammonia, nitrate, total alkalinity, calcium, magnesium, sulphate, total phosphorous and dissolved oxygen. The collected water samples were brought in cooler and analyzed in Nepal Environmental and Scientific Services (NESS) laboratory at Thapathali, Kathmandu, Nepal. From each spot, 500 mL of brim-full water sample was collected for measuring dissolved oxygen (DO) and one liter for measuring other chemical parameters. About 2 mL of manganese sulfate was first added to sampled water to stop the entry of oxygen. Similarly, 2 mL of alkali-iodide azide was added in the sampled water for fixing the sample, which was later tested by using standard methods (Appendix I).

Data analysis

Index of dispersion, defined as the ratio of the variance $(\sigma)^2$ to the mean (μ)) was used to observe the dispersion pattern in the river habitat. Pearson's correlation coefficient (r) was referred to test the linear association between seasonal period (pre-monsoon and monsoon) and habitat type (meander, straight channel and confluences). The abundance of dolphin was estimated as in Vidal (1997), a product of mean sighting per river segment and total perpendicular distance covered from observation point (T) in each river segment (Table 1) using formula, as given below equation (1). Mean sighting was defined as river distance surveyed (t) divided by the number of dolphins sighted (n) in the river segments.

$$N = \left(\frac{t}{n}\right) * T \tag{1}$$

Wilcoxon signed-rank was used to test significant differences in water quality parameter across two time period.

RESULTS

Distribution

The survey for the river segments showed that, the dolphins had clumped distribution ($\delta^2/\mu>1$; index of dispersion) pattern in pre-monsoon period of 2018 (n_2= 36, μ_2= 1.33, δ^2_2= 2.55) and monsoon period of 2016 (n_1= 16, μ_1= 3.93, δ^2_1= 4.18). One dolphin per 1.65 kilometers was present in the pre-monsoon period whereas one dolphin per 1.36 km in monsoon period (Fig. 3). Of different river segment, dolphins were mostly sighted in Kulariya River (Table 1). Dolphins were largely found in a straight channel in pre-monsoon of 2018, whereas their availability was higher in the meander channels during monsoon period of 2016 (Table 2).

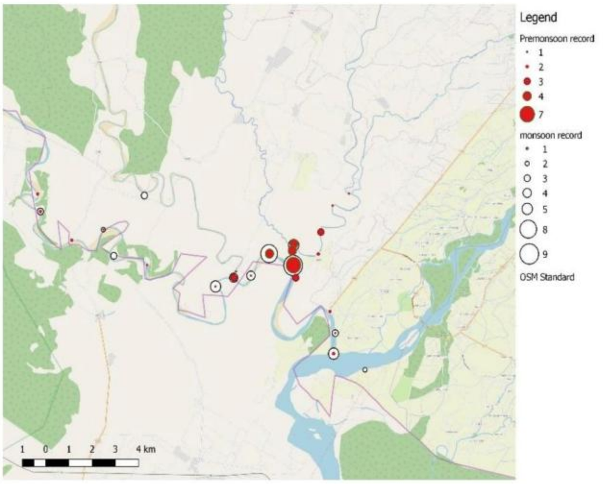


Fig. 3. Dolphin census at various observation spots during pre-monsoon and monsoon period

Table 1. Information on number of dolphin sighted in different river segments

River segment	Number of sighting		Distance surveyed (km)		Mean sighting (per km)		Perpendicular river distance from observation spot (km)		Abundance	
	PM	M	PM	M	PM	M	PM	M	PM	M
Mohana	14	25	25.16	25.16	1.797	1.006	0.634	0.508	1.139	0.511
Kandra	4	7	14.54	14.54	3.635	2.077	0.119	0.109	0.433	0.226
Kada	4	3	13.75	13.75	3.436	4.583	0.003	0.003	0.010	0.014
Pathariya	15	17	16.54	16.54	1.103	0.973	0.819	0.533	0.903	0.519
Kulariya	11	6	5.118	5.118	0.465	0.853	0.023	0.007	0.017	0.006
Jamara	0	0	4.20	4.2	0	0	0		0	0
Karnali	0	2	0	2	0	1	0	0.69	0	0.69
Total	**48**	**60**	**79.308**	**81.308**	**1.652**	**1.355**	**1.598**	**1.85**	**2.640**	**2.507**

PM = Pre-monsoon; M = Monsoon

Table 2. Availability of dolphin across different habitat in different seasons

Habitat type	Pre-monsoon	Monsoon
Confluence	17	21
Meander	12	29
straight channel	19	10
Total	48	60

Physico-chemical parameters

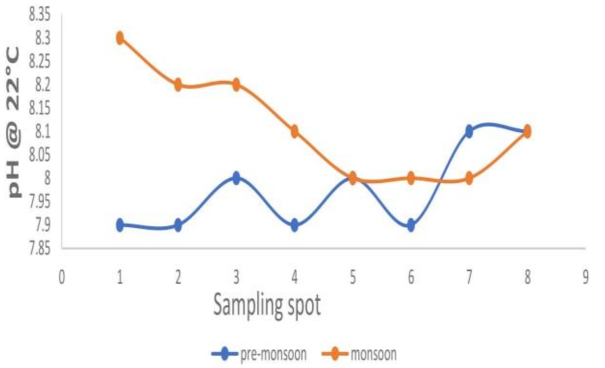
Distinct parameters of habitat were obtained from 8 different spots across river segments (Fig. 4). Test of Wilcoxon sign rank showed water quality does not differ significantly in the two seasons at different sites for all tested parameters ($p<0.05$). Physicochemical parameters test revealed that habitat is slightly alkaline with high turbidity and less vulnerable to an acid deposition with a high amount of total phosphorous in both seasons.

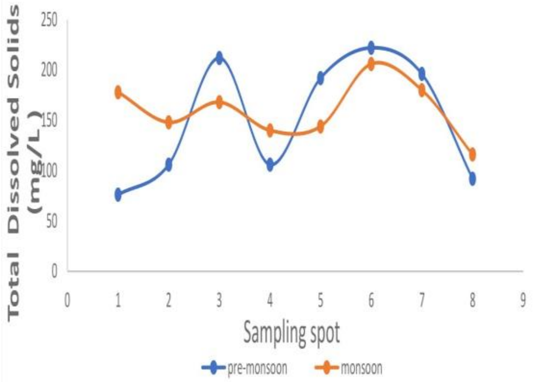
DISCUSSION

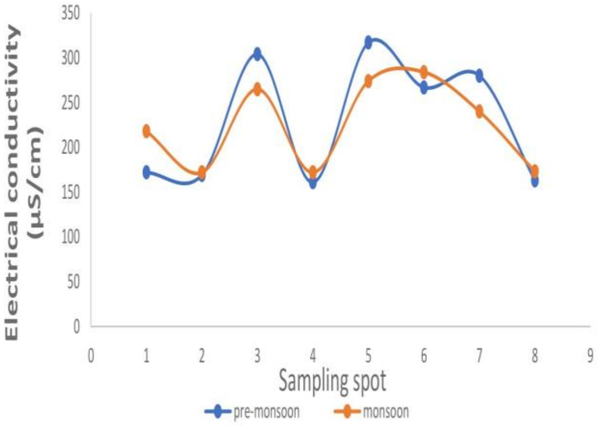
The present study has provided information on the physicochemical parameters and population status in the Mohana River segment. The physicochemical parameters on tested water samples were; slightly alkaline with high turbidity and low vulnerability to acid deposition. Total phosphorous was higher, which indicated high eutrophication productivity range for both seasons (pre-monsoon and monsoon). However, due to a month-long "Dolphin festival" organized by local communities, population census during monsoon period for 2018 was not be reported. The abundance of dolphin concerning physical habitat was examined in this study, not with physicochemical parameters. Therefore, the reported census from the different year for monsoon period bears no implication on the relationship between population and habitat quality. The physical characteristic of the habitat was not altered and hence should not be ambiguous.

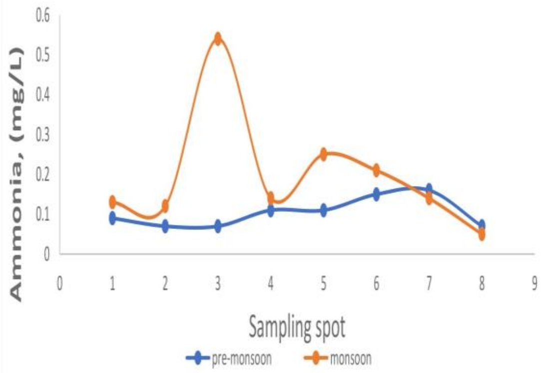
With the available information, the highest number of individuals in 2018 was reported from spot-2 and less individual (i.e., one) from spot-1 (excluding the instances which reported no presence). The high number of dolphins corresponded to a higher level of turbidity, total suspended solids, nitrates, calcium, total phosphorous, and dissolved oxygen compared to two spots. In contrast, the levels of electrical conductivity, total dissolved solids, total alkalinity, and magnesium were low. Nonetheless, dolphin was observed in segments that had a different level of parameters. It is concluded from the observations that pH ranging from 7.9-8.1, electric conductivity between 161-304 (µS/cm), turbidity from 50-430 (NTU), total suspended solid between 92-1672 (mg/L), total dissolved solid from 76-222 (mg/L), ammonia between 0.07- 0.16 (mg/L), nitrate from 0.05-0.52 (mg/L), total alkalinity from 126-199 (mg/L), calcium between 32.86-49.7 (mg/L), magnesium from 6.32-13.12 (mg/L), sulphate less than 4.94 (mg/L), total phosphorous between 0.16 to 1.04 (mg/L) and dissolved oxygen from 75 to 102 (% saturation) in pre-monsoon period were tolerable for dolphins.

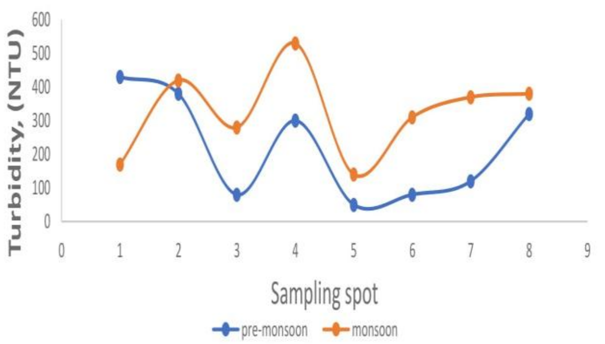
It cannot confirm the scenario was beneficial for dolphin. However, current information can assist in the future assessment of habitat. Parameters such as electric conductivity for a healthy freshwater system, usually ranges between100-2,000 µS/cm (Clean Water Team, 2004). Parameter such as pH in the study habitat was within a suitable range since Bryan (2004) reported that pH values between 6.5 and 9.0 are satisfactory for fish and other freshwater aquatic life. High turbidity inhibits the growth of submerged aquatic plants and clogs gills of sensitive fishes causing their death (Ryan, 1991) resulting in decrease of several fish species (Schulz, 1996). A study by Derry *et al.* (2003) showed that increase of the total dissolved solid (TDS) from 270 to 1170 mg/ L led to almost wiping of Coontail (*Ceratophyllus demersum*) and Cattails (*Typha* sp.) in the aquatic system. The TDS impacts at different life stages of the organism- e.g. Alaska fish species were affected during fertilization due to the presence of $CaSo_4$ (Stekoll *et al.*, 2003; Brix & Grosell, 2005). Besides, high TDS in combination with low water pH was detrimental for the survival of fishes (Nyanti *et. al*., 2018). Similarly, ammonia can have severe consequences on aquatic life. It affects the central nervous system resulting in death (Wicks *et al.*, 2002) as well as reduces hatching success and growth rate (EPA, 1999). Present study showed two different scenarios in case of nitrate; pre-monsoon level highlights the habitat is of pristine with high biodiversity values whereas monsoon level shows that environments have seasonally influenced concentrations for periods of 1-3 months (Hickey, 2013). The acid-neutralizing ability of water helps resist an immediate change in pH level. In general, fresh-water alkalinity level is 30 to 90 mg/L (EPA, 1997), but present study showed a higher level than the normal. Other study showed that low calcium concentrations limit the distribution and success of calcium-demanding freshwater crustaceans in soft-water localities (Rukke, 2002). Another critical parameter in aquatic ecosystem is sulphate, which is an essential nutrient for tissue growth, but can be detrimental at higher concentrations. At higher concentration, sulphate releases metals from sediments which in turn increases alkalinity and eventually affect organism with a low tolerance for high pH level (Sprague *et al.*, 2007). In a non-polluted natural water, total phosphorous extends over <1 µg/L in ultra-oligotrophic waters, to >200 µg/L in highly eutrophic waters but uncontaminated freshwaters contain between 10 to 50 µg/L (Wetzel, 2001) which highlights that the studied-habitat ecosystem might be unproductive.

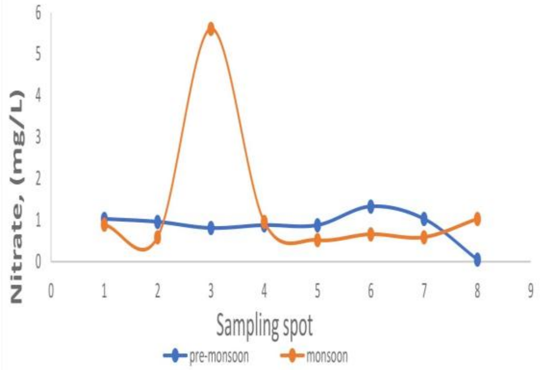

pH @ 22°C
Sampling spot
pre-monsoon
monsoon

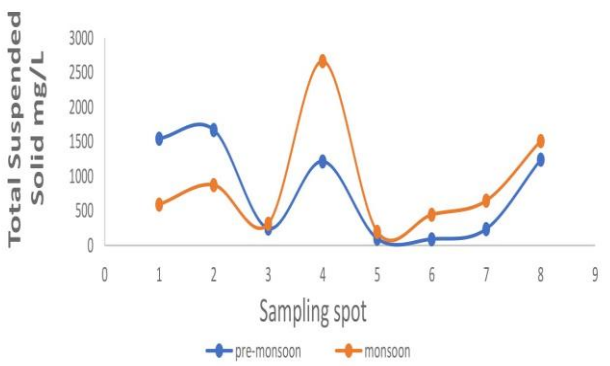

Total Dissolved Solids (mg/L)
Sampling spot
pre-monsoon
monsoon

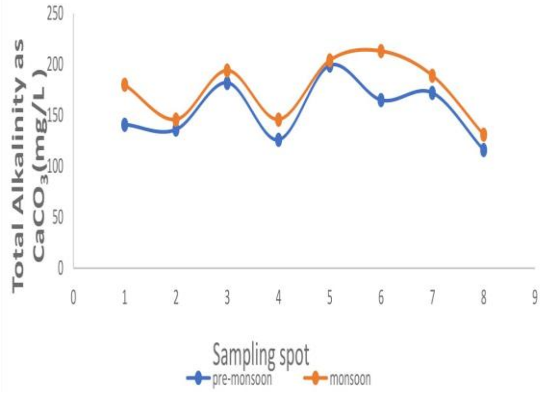

Electrical conductivity (µS/cm)
Sampling spot
pre-monsoon
monsoon


Ammonia, (mg/L)
Sampling spot
pre-monsoon
monsoon


Turbidity, (NTU)
Sampling spot
pre-monsoon
monsoon


Nitrate, (mg/L)
Sampling spot
pre-monsoon
monsoon


Total Suspended Solid mg/L
Sampling spot
pre-monsoon
monsoon


Total Alkalinity as CaCO3(mg/L)
Sampling spot
pre-monsoon
monsoon

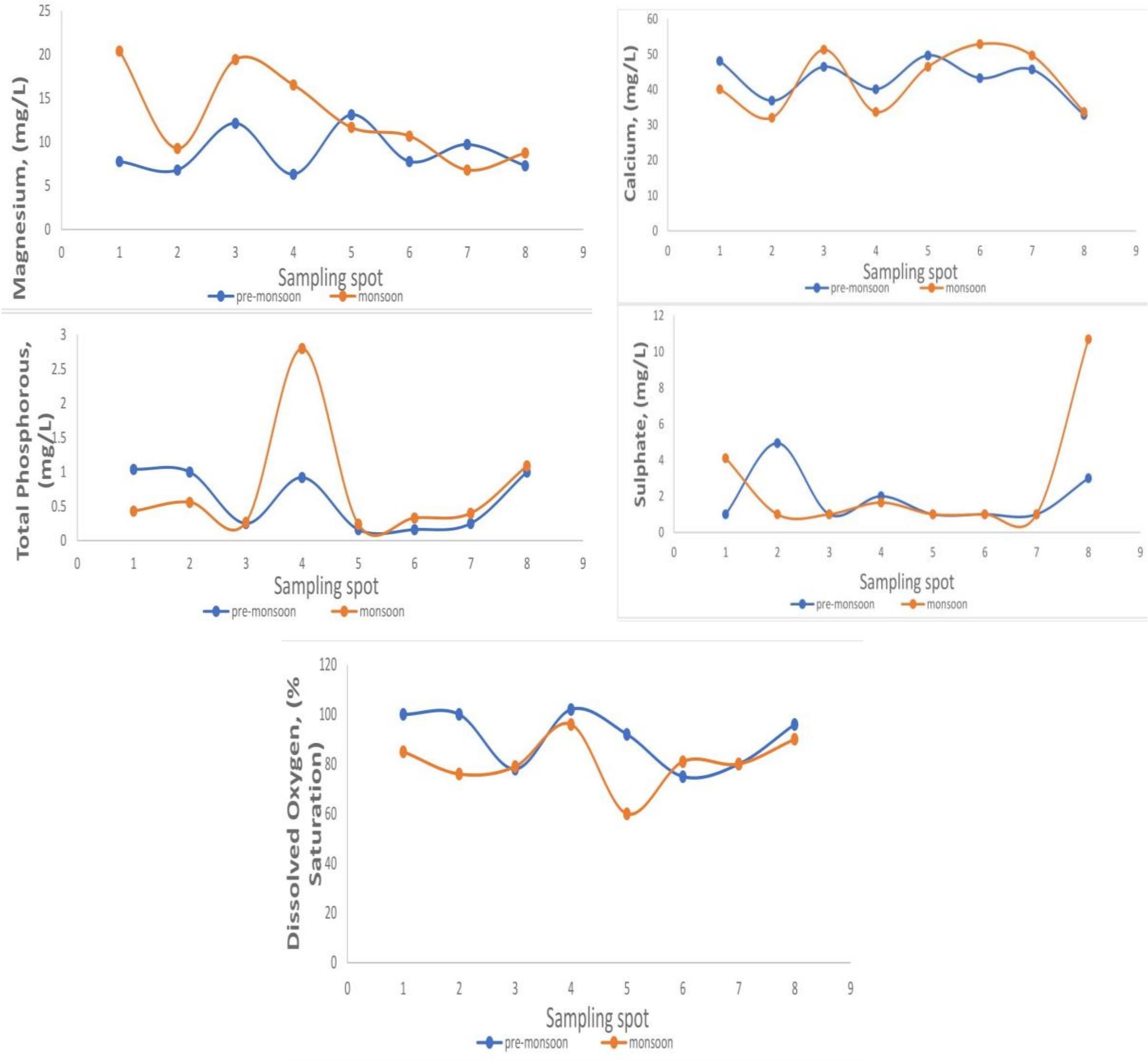


Fig. 4. Physico-chemical condition of river segment during pre-monsoon and monsoon periods

The dissolved oxygen parameter, however, suggests that the river system has a high level of oxygen concentration during pre-monsoon period. Resource considerations suggest net oxygen gain per unit of energy expenditure will be most advantageous as the costs and the risk of predation among fishes vary with oxygen availability (Kramer, 1987). Present study also reported percent saturation above 100, which is due to the photosynthesis that adds oxygen produced in the water, potentially bringing it above 100 % saturation. Future investigation on the organic component is also required as Senthilkumar *et al*. (1999) had shown a high concentration of organic compound from tissues of dolphin. Impact of these parameters on dolphin biology can provide a realistic understanding of how pollutants affect.

In previous studies, WWF Nepal (2006) has highlighted that the distribution of dolphin in Mohana was dependent on the water level. There were a high number of dolphins in the river system during the monsoon period. Though there was no data on the depth of the river. Paudel *et al*. (2015) stated that river depth plays a crucial role in the presence and absence of dolphin. Still, our observation indicated that flow (speed) of the river, as well as rocky riverbed, can be an impeding factor for mobility. Rocky riverbed and fast-flowing river might be the reasons for hindered dolphin's movement to Spot 8.

Even though the main Karnali channel is much deeper, dolphin seldom visited this channel. This study could not report many sightings from a major river channel of Karnali segment, and most of the reporting was from low laying rivers with less depth and less flow of water. Moreover, distribution of dolphins might depend upon water level, in addition to prey stock and the absence of higher speed of water flow. A study has suggested that a decrease in stream velocity resulted in increased resource abundance and stability, which supported many other species (Smith, 1993).

For the past couple of decades, estimate showed that dolphins' number has been consistently reduced (WWF Nepal, 2006) since in 1983. Shrestha (1989) recorded 20 dolphins along the Geruwa segment, in 1990 only two dolphins were recorded (Smith, 1993), but four years later, four dolphins were sighted (Timilsina *et al*., 2003). However, the present observation has suggested an increase in the number of sightings and has listed 60 individuals instead of 63 numbers because of unclear information on the GPS location of one of the spots during the survey. This increment in sightings might have resulted from surveying larger area. In the meantime, community-level initiatives must have created a favorable environment for dolphins. Community awareness has created a consciousness among the local people for conservation in the study area. It was noticed that young kids to older individuals were supportive and enthusiast about conserving habitat.

Shrestha (1989) found mahasheer (*Tor putitora*), and siloroid catfish (*Bagarius bagarius*) in the stomach of dolphin and Smith (1993) listed fishes such as *Bariliusbarna, Oxyasterbacaila, Cirrihinusmrigala, Aspidoparia mora, Pseudechemesi sulcatus, Barilus barna, Mastacembelus armatus* to be food items of dolphin. Altogether 49 fish species were recognized, and the list was prepared based on the local name provided by the local fishing community as well as through observation of fishes caught by a fisherman at various locations of dolphin conservation centre. Rigorous and intensive fish sampling methods were not adopted. However, this does not necessarily mean that dolphin feeds on every species of the fish.

A new water condition was presented to highlight agricultural and human activities in adjoining the river habitat in this study. This information will be useful for the future assessment of the quality of habitat and, increment or decrement of dolphin in the river as a result of changes in river quality. It can help determine the threshold of chemical in the river that can sustain dolphins. It cannot be confirmed at this point if this type of water quality affects positively or negatively to the dolphin because we do not have previous chemical record from this site. But the studies from other areas have highlighted the accumulation of toxicity in dolphins (Kannan, 1997). Looking ahead into the future of the species in the river segment, dolphin monitoring should be carried out every year.

Nevertheless, community initiatives for conservation have been commendable for the sustainability of dolphin in the river segments. In addition, dolphin sanctuary should be initiated as done in India or species conservation efforts highlighted by WWF Nepal (2006) should be implemented which will ensure the future sustainability of the species in the habitat. Further, we need to confirm the present population found in Nepal River is fragmented population as a result of Kailashpuri barrage in India or free-ranging population. Since the river flows across the international boundary, trans-boundary conservation initiative is necessary.

CONCLUSION

The present study finds that the habitat had deposition of ingredients that can be related to chemical fertilizers used in the fields. The information gathered from the study can help in monitoring and developing plans for Ganges river dolphin. The data can be a reference for dolphin habitat, for future work to determine the relationship between degradation of habitat and population of dolphin.

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APPENDIX I

Standard methods adopted by NESS laboratory for determining of the physicochemical parameters of water

Physico-chemical parameters	Test methods
pH @ 22° C	Electrometric, 4500 - H^+ B, APHA
Electrical conductivity, (µS/cm)	Conductivity meter, 2510 B, APHA
Turbidity, (NTU)	Nephelometric, 2130 B, APHA
Total suspended solids, (ml/L)	Over drying method, 2540 D, APHA
Total dissolved solids, (mg/L)	Over drying method, 180°C, 2540 C, APHA
Ammonia, (mg/L)	Direct Nesslerization, 4500 – NH_3 C, APHA
Nitrate, (mg/L)	UV Spectro-photometric screening, 4500 – NO_3^- B, APHA
Total alkalinity as $CaCO_3$, (mg/L)	Titrimetric, 2320 B, APHA
Calcium (mg/L) **Magnesium (mg/L)**	EDTA titrimetric, 3500-Ca B & 3500 - Mg B, APHA
Sulphate (mg/L)	Gravimetric method, 4500- SO_4^{-2} C , APHA
Total phosphorous, (mg/L)	Ascorbic acid, 4500- P E, APHA
Dissolved oxygen, (% saturation)	Winkler azide modification, 4500- O C, APHA

Source: Laboratory Protocol, NESS; Note: The gravimetric analysis was carried out in controlled temperature of 20° C.