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Ecological Impacts and Status of Marsh Crocodile on Selected Wetlands of Anand and Kheda Districts, Gujarat, India

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ABSTRACT

Present study deals with the water quality and population status of Marsh crocodiles (*Crocodylus Palustris*) in central Gujarat region. Water quality analysis of three ponds, (S1) Petli, (S2) Deva and (S3) Heranj, was carried out during December 2020 – February 2021. The physico-chemical parameters like Water temperature, pH, Conductivity, Salinity, Turbidity, Acidity, Sodium (Na), Potassium (K), Biological Oxygen Demand (BOD), Ammonical nitrogen, Chemical Oxygen Demand (COD) and heavy metals were analyzed and the correlation coefficient between different Physico-chemical parameters was also worked out. The analysis revealed a strong positive correlation of salinity with conductivity and Na and pH were found negatively correlated with temperature. It was observed that all the parameters were within the prescribed limits except ammonical nitrogen which was slightly higher in S2 pond as per the standards given by BIS (2012). A survey of the ponds revealed a total of 105 Marsh crocodiles in Petli, Deva and Heranj majority of which were located in Deva (58).

Keywords Wetland survey, Population of crocodiles, Water quality, Marsh crocodile.

INTRODUCTION

Water is mainly used for irrigation, domestic and industrial requirements in all parts of the country (Kumar *et al*. 2017). Water scarcity impacts the quality of life. The availability of clean water is an important factor for developing countries. Presently India is facing clear water crisis due to the negligence of mankind towards water resources and the current deteriorating environmental condition, which is the main reason behind the unequal distribution of safe water to the majority of people (Majumder and Kumar Dutta 2014).

Water is a very essential and valuable resource for the existence of all living organisms on this planet which includes various floral and faunal species, including microscopic phytoplankton and zooplanktons (Majumder and Kumar Dutta 2014). Naturally found surface water bodies like ponds, rivers and streams are loaded with organic and inorganic pollutants. Its

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physico-chemical characteristics usually determine the quality of water. It has an indirect association between aquatic organisms and hydro-biological parameters in a freshwater body.

For several decades, India's water quality has deteriorated due to the excessive release of industrial waste and domestic sewage in the surface water bodies. It has a devastating impact on the species of stagnant surface water bodies like lakes and ponds. Fishes are majorly affected both directly and indirectly due to this uncontrolled release of pollutants by industrial and domestic means. Hence, it becomes highly significant to check out the water quality for the presence of pollutant affecting aquatic organisms.

The Mugger or Marsh crocodile (*Crocodylus Palustris*) is one of the world's largest carnivores (Whitaker 1987). The functioning of freshwater environments is governed by this predator. Therefore, its existence is highly crucial concerning India's wildlife conservation and cultural diversity, especially in Gujarat (Bhatt *et al*. 2013).

Crocodylus Palustris is a "vulnerable" species (Choudhury and de Silva 2013). In India, crocodiles belong to schedule I animals. They are found in both protected and unprotected areas. The average length of Marsh crocodile ranges from 12-13 feet. Usually, young and adult mugger crocodiles dig burrows to maintain their body temperature as they are cold-blooded individuals. They maintain their body temperature between 30 - 33˚C (Webb and Manolis 1989). Individual crocodile can lay up to 35-40 eggs depending upon habitat and climatic conditions during the summer season (Lang 1989).

The present study was undertaken to access the quality of water by determining the physico-chemical properties of water and to determine presence of pollutants in three ponds of Anand and Kheda district, i.e., (S1) Petli, (S2) Deva and (S3) Heranj, during December 2020 to February 2021.

MATERIALS AND METHODSOLOGY

Study area

Based on preliminary study, (Fig. 1) three ponds were selected for the present investigation focusing on crocodile-rich pond sites of Anand and Kheda districts. These ponds were under the influence of several domestic activities carried out by the population of nearby villages.

(S1) - Petli Gam Talav [L 22.598626°, L 72.757210°]

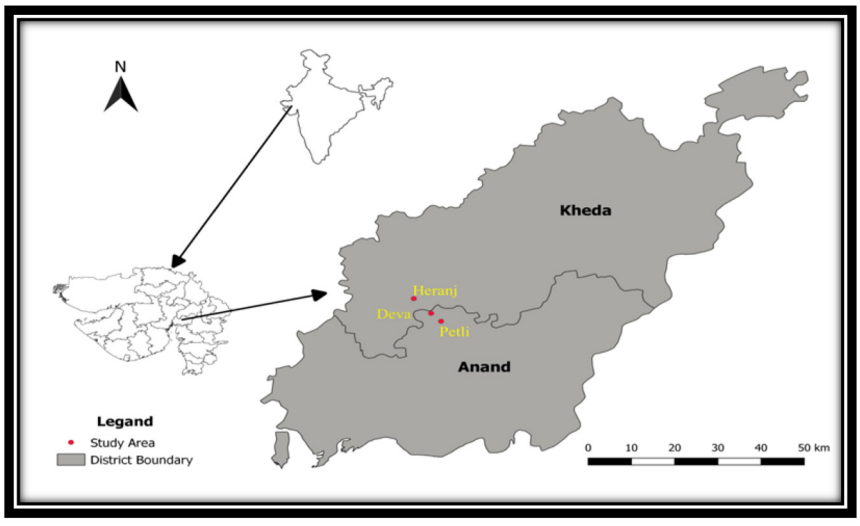

Fig. 1. Study area.

is small and a permanent water body with 19,621.23 m^2 area. Man-made activities such as domestic waste dumping and religious practices were observed in its surroundings, resulting in excessive dumping of biodegradable waste such as flowers, coconut shells, milk increasing the organic load of the water body. Moreover, defecation by humans and cattle also cause pollution at the site.

(S2) - Deva Bhabharam Talav [L 22.620502°, L 72.735051°] is of 130,540.85m^2 area. Domestic activities such as washing clothes and utensils, cattle bathing, are regularly carried out in this pond. The remnants of the crematory ground of this village are channelized into the pond. Recently, the water canals have been narrowed down due to the ongoing road width expansion project in this region. A large number of crocodile dens are present throughout this canal. All these activities make strong impact on this breeding population of the crocodiles.

(S3) - Heranj Gam Talav [L 22.660163°, L 72.696532°] having an area of 115,000.67m^2. The soil at this site is currently being excavated at frequent intervals by Panchayat for the railway construction and expansion of pond. Several other anthropogenic activities were observed surrounding the pond such as defecation and bathing of domestic animals. It also receives the waste from the nearby temple and the residential area in the form of run-off water and from open waste dumping of leftover food, finally increasing the organic load of the pond. Moreover, non-biodegradable waste such as plastic and styrofoam plates were accumulated in the surrounding of the pond.

In 2019, a non-fatal human crocodile conflict was also reported at (S2) study site. Besides, three Human Crocodile Conflicts have been recorded in the Anand and Kheda districts, two of which were fatal attacks and one non-fatal attack.

Direct observations

The location of the pond was marked with Global Positioning System (GPS). All the data were collected between 8:00 am to 4:00 pm. Every sight was visited five times during the study period. Standard protocols (Track surveys) were used for crocodile spotting as per the methods of (Cherkiss *et al*. 2004). The spotting of a crocodile was done with the help of Nikon Aculon binocular A211 (8 X 42). The indirect evidence of crocodiles like pugmarks, tail marks, dens or scat from the surrounding area was also captured for validation through Nikon D3500 DSLR camera. All the crocodiles were categorized in different sizes, i.e., <1m, 1-2m, 2-3m, >3m. The size of the animal was predicted by a body length or snout size and distance between two eyes. Present data is of winter count where surveys were carried out during the daytime. The study area map was designed with the help of Quantum GIS Software, and the graph were generated using free software Microsoft Excel.

Method of sampling

The water samples were collected from each pond from five different places, and a composite sample of 500 ml was prepared. Sampling was done with the help of a small polyethylene bucket tied to a rope. Samples were collected in sterile glass bottles. Water samples were withdrawn from a depth of 1.5 ft approximately. Standardized operating procedures given by (Maiti 2004) was followed for the analysis. Various physico-chemical parameters like Biological Oxygen Demand (BOD), pH, Chemical Oxygen Demand (COD), Conductivity, Ammonical Nitrogen, Salinity, Acidity and essential and nonessential heavy metals were analyzed. Salinity was measured in all the sites with a portable salinity tester –HI98319 of HANNA. The pH was measured with Hanna instrument (pHep HI96107) pocket size pH meter. Conductivity was measured with Hanna digital instrument HI96304 (DiST 4). Heavy metal analysis was carried out with ICP- OES.

RESULTS AND DISCUSSION

Physico-chemical analysis of water

Temperature plays a vital role in the growth of flora and fauna diversity of the pond (Rajagopal *et al*. 2010). The average water temperature at all sites ranged between 26-33˚C (Table 1). The pH mostly regulates all the biochemical reactions of the pond.

Table 1. Physico-chemical analysis of water.

Parameters	S1	S2	S3	Unit
Temperature	26.8	27.3	32.2	˚C
pH	7.5	7.3	7.2	-
Conductivity	1440	1140	1160	µs/cm
BOD	3.8	5.7	4.3	mg/l
COD	15.8	19.5	22.9	mg/l
Turbidity	1	1.4	0.7	NTU
Ammonical Nitrogen	0.23	0.72	0.18	mg/l
Na	194	165	149	mg/l
K	100	78	28	mg/l
Fe	0.0307	0.0960	0.0395	mg/l

The pH value obtained at all the three sites Petli (S1), Deva (S2), Heranj (S3), was 7.5, 7.3 and 7.2, respectively. S1 > S2 > S3 obtained the highest concentration. The desirable limit given by (BIS 2012) is 6.5 to 8.5 for inland surface water bodies, hence all data obtained were under permissible limits. Results were in accordance with (Bhagde *et al*. 2020).

Conductivity indicates the total amount of salts present in water. It is also a useful tool for evaluating the purity of water (Acharya *et al*. 2008). In the present investigation, conductivity values obtained in all three sites S1, S2 and S3 were 1440, 1140 and 1160 µs/cm, respectively. The highest concentration obtained was for S3 > S1 > S2. Similar results were also observed by (Goyal *et al*. 2021).

BOD levels in the aquatic bodies are very significant as they highlight the rate at which the microflora and fauna consume the oxygen for various metabolic activities. It also reflects the pollution status of the body. Biological Oxygen Demand (BOD) range in all three ponds was between 3.8 – 5.7 mg/l. Similar results were also observed by (Munni *et al*. 2015).

Chemical Oxygen Demand is the amount of Oxygen required for chemical oxidation for both organic and inorganic matters. All three sites S1, S2 and S3 showed chemical oxygen demand (COD) values as 15.8, 19.5 and 22.9 mg/l respectively. The ideal levels for fish farming should be below 50mg/l, according to (Santhosh and Singh NP 2007). The present finding is accordance to the findings of (Abir Shib 2021). COD levels showed that some of the non-biodegradable oxygen depending pollutants are present in the pond.

The turbidity of water is due to suspended particulates present in it, and these suspended particles make the solution cloudy (Nandal *et al*. 2020). The data obtained for all the three sites showed values as 1, 1.4, 0.7 Nephelometric Turbidity Units (NTU), for S1, S2 and S3 respectively. The maximum values were obtained in S2 (1.4 NTU), and the minimum values were obtained in S3 (0.7 NTU). (BIS 2012) specifies a tolerable maximum of 5 NTU. As a result, turbidity for all the three sites was within the acceptable range.

The Ammonical nitrogen values obtained for all the three sites S1, S2, S3, were 0.23, 0.72, 0.18 mg/l, respectively. The concentration in decreasing order recorded was S2 > S1 > S3. The acceptable limits given by (BIS 2012) is 0.5 mg/l in the case of inland surface water bodies. The values were within range except S2. Excess ammonia can build up in the body, causing changes in metabolism and an increase in body pH. Different species may tolerate varying levels of ammonia, but in general, the lower the ammonia level, the better. Loss of balance, hyperexcitability, increased respiratory activity, oxygen consumption, and heart rate may occur in fish. Fish may endure convulsions, unconsciousness and death if their ammonia levels are too high. The fatal dose for several fish species ranges from 0.2 to 2.0 mg/L, according to experiments. Similar results were also observed by Brian (2014).

Among all the three ponds, salinity showed a strong positive correlation with conductivity and Na (Table 2). Similar results were also observed (Dixit *et al*. 2015). The pH showed positive correlation with Salinity, Na, K. As salinity increases, pH will also increase. Results were in accordance with that of (Harcourt *et al*. 2007). The pH also had a negative correlation with temperature similar, results are also reported by Arya *et al*. (2011).

Heavy metal analysis of water

Heavy metal analysis was carried out for six heavy metals Pb, Cr, Cd, Zn, Co and Ni. The results revealed their values below detection limits. This indicates that there is now no influx of heavy metal into all of the sites. Furthermore, all of the wetlands are available on lease for fish farming, as there is no accumulation

Table 2. Correlation coefficient of specific physico-chemical parameters at all the three ponds Petli Deva and Heranj. Red color cells which have values greater than 0.8.

	Salinity	Ammonical nitrogen	COD	Fe	Conductivity	Na	K	Turbidity	pH	BOD	Tempe-rature
Salinity	1										
Ammonical nitrogen	-0.8171	1									
COD	0.9394	-0.5699	1								
Fe	-0.7435	0.9930	-0.4692	1							
Conductivity	0.9915	-0.7351	0.9760	-0.6501	1						
Na	0.8533	-0.3966	0.9803	-0.2857	0.9139	1					
K	0.5942	-0.0217	0.8339	0.0962	0.6937	0.9264	1				
Turbidity	-0.6547	0.9707	-0.3559	0.9923	-0.5507	-0.1645	0.2191	1			
pH	0.8660	-0.4193	0.9849	-0.3095	0.9237	0.9997	0.9167	-0.1890	1		
BOD	-0.1211	-0.4734	-0.4540	-0.5739	-0.2492	-0.6209	-0.8704	-0.6711	-0.6012	1	
Temperature	-0.8417	0.3764	-0.9758	0.2646	-0.9048	-0.9998	-0.9344	0.1429	-0.9989	0.6379	1

of heavy metals in the fish, indicating that the fish are of good quality and fit for consumption both by humans as well as crocodiles.

The concentration of iron obtained for all the three sites S1, S2, S3 was 0.0307, 0.0960, 0.0395mg/l, respectively. The highest concentration obtained was for S2 > S3 > S1. The desirable limit given by the (BIS 2012) is below 0.33mg/l for the inland surface water bodies, hence all the data obtained were under permissible limits.

In all a total of 105 crocodiles were spotted at all these three ponds. S1 has 19 crocodiles, S2 has 58, and S3 has 28 crocodiles, including juveniles, sub-adult, adult and large adult individuals. S2 has highest population of 58 followed by S3 with 28 and S1 with 19 crocodiles. The characterization of all the crocodiles into five categories <1m, 1-2m, 2-3m >3m according to size is given in (Fig. 2.). The maximum crocodile size found was between 1-2 m. Similar work was also carried out by (Khan *et al*. 2015) and concluded the presence of 144 breeding populations of marsh crocodiles in Karachi with 98 adults, 28 sub-adults and 15 juveniles.

Crocodiles being a poikilothermic animal cannot maintain their constant body temperature as mammals and birds. They prefer 30 -33ºC temperature (Webb and Manolis 1989). During cold weathers they bask in open sun to maintain body warm an in hot climatic conditions they prefer shaded areas or the dens to avoid overheating. Thus, they move in and out of the water frequently. Crocodile activity was observed as shown in (Fig. 3) during winter at all three sites, S1, S2 and S3, and revealed crocodiles basking the entire day between 9:30 a.m. and 4:30 p.m.

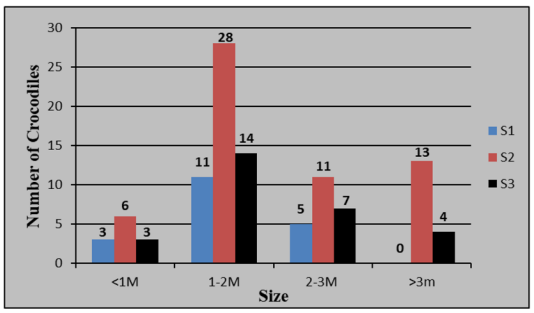

Fig. 2. Size of crocodiles.

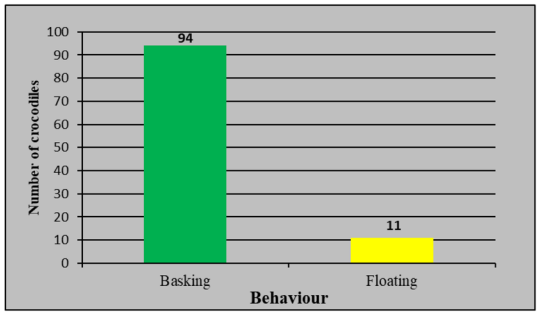

Fig. 3. Activity of crocodiles.

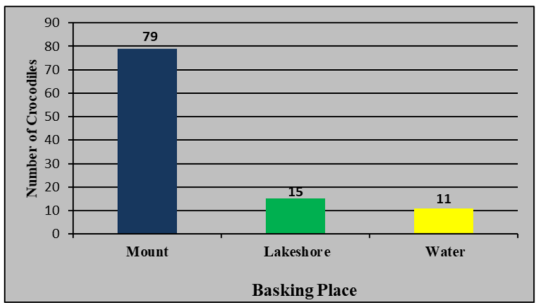

Fig. 4. Preferred places for basking.

Preferred place for basking was noted for all three sites S1, S2, S3 (Fig. 4.). It was observed that maximum crocodiles prefer basking on Mount > Lakeshore > Water. Large crocodiles prefer basking on mounts, Juvenile prefers lakeshore as it has vegetation covered and can easily hide them from being attacked (Figs. 5 and 6).

Future management implications

All the Gram-panchayats should work together and protect this keystone species.
No waste should be allowed to be dumped near or in the pond.
Stone pelting on crocodiles should be stopped.
Awareness programs should be carried out regularly.
Fencing the ponds should be as an essential measure to avoid human crocodile conflict.

Fig. 5. Juveniles basking in vegetation

Fig. 6. Crocodiles basking on mount.

CONCLUSION

Based on the present study, the breeding Marsh Crocodile population was about 105 individuals, in which Deva has a maximum of 58 individuals, followed by Heranj 28 and Petli with 19 individuals, respectively.

Water sample analyses for physico-chemical characterization from all the three ponds of Petli, Deva, and Heranj revealed that the three sites had good water quality. Ammonical nitrogen levels was slightly higher than the prescribed limits. However still, the domestic waste should not be dumped in the pond. It is crucial to protect this vulnerable species and its dwindling population in Gujarat.

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