*Biological Forum – An International Journal* **9**(1): 87-94(2017)

**ISSN No. (Print): 0975-1130**
**ISSN No. (Online): 2249-3239**

# Ecology and Diversity of Selected Aquatic and Semi-Aquatic Fauna of Baanganga Wetlands, Haridwar (Uttarakhand, India)

***Archana Bahuguna* and Indu Sharma*****
**Northern Regional Centre, Dehradun (Uttarakhand), INDIA*
***Zoological Survey of India, High Altitude Regional Centre, Saproon, Solan (Himachal Pradesh), INDIA*

*(Corresponding author: Indu Sharma)*
*(Received 24 January, 2017, Accepted 20 February, 2017)*
*(Published by Research Trend, Website: www.researchtrend.net)*

**ABSTRACT: During the presents studies the diversity (fishes, amphibians and turtles) and ecology of Baanganga wetlands, Haridwar has been undertaken. The studies revealed the occurrence of 19 species of fishes, 03 amphibians and 05 species of freshwater turtles in various water bodies of Baanganga wetlands. The Physico-chemical properties of water showed that the habitat is deteriorating. The increased pH in some water bodies, low oxygen in water, high level of chloride ions were noted to be harmful for the habitat of aquatic and semi aquatic fauna. We suggest options for conservation of these wetlands.**

**Key words**: Baanganga wetland, freshwater turtles, anurans, pisces, ecological study water analysis.

## INTRODUCTION

Wetlands are one of the world's productive environments. They provide immeasurable benefits *viz.* food, flood control, climate change mitigation and biodiversity. They act as biofilter, as they intake large amount of organic as well as inorganic nutrients from the eutrophic water bodies/nutrient enriched pollutant through various dynamic processes, e.g. water cycle, nutrient cycle and food chain, therefore, known as 'Kidney of the Landscape' or 'Biological Super Market' by the experts or the areas where the soil is saturated with water are crucial incubators known for high species diversity (Allen-Diaz *et al.* 2004). They harbor variety of fauna that inhabits in terrestrial, semi-aquatic and aquatic environments. Baanganga wetland, Indrishpur village in Haridwar district lies between Hastinapur Wildlife Sanctuary in Uttar Pradesh and Jhilmil Jheel Conservation Reserve in Uttarakhand. It represents Riverine wetland ecosystem. Baanganga wetland, a 45 km long channel originates near Bishenpur and flows in Idrishpur-Chakheri forestblock of Haridwar district in Uttarakhand. The construction of a dam across river Ganga, near Baanganga and other anthropogenic activities have led to the conversion of channel into isolated water bodies.. These wetlands are still considered as major habitat for wintering waterfowl, though they are surrounded by large agricultural fields and human settlements (Adhikari 2008). The information regarding fauna of the Bannganga is limited. Some work has been undertaken on fishes (Kumar (2007) and information of birds and mammals is available on the internet. The Indo-Gangetic plain and the *Terai* region represents 20 species of freshwater turtles (Das 2002, Rao 1990). The present studies illustrate the diversity of freshwater fishes, amphibians and turtles based on collection and sightings in and around Baanganga. Water quality parameters of the area and suitability for aquatic fauna are also described.

## MATERIAL AND METHODS

**Study area**: Baanganga wetland (78°2'43"E to 78°2'15" E and 29°44'5" N to 29°36'01") is located 60 km south-west of Haridwar on Laksar-Purkaji road, and it has about 10 $km^2$ water spread area. Land use and land cover include; water bodies (55%), marsh (4%), islands (15%), moist shores (8%) and upland (18%) (Adhikari, 2008).

Monthly surveys were conducted along the Baanganga River covering seven localities (Table 1) during 2008 to 2009. The wetland was divided into five land use categories: water bodies, marshy area, islands, moist shores and upland as per Adhikari, 2008 and surveyed randomly for freshwater fishes, amphibians and turtles. A minimum of 10 water samples were collected from each (eight) water bodies for analysis (Table-5 & 6). The ambient temperature of the atmosphere and of surface water was taken by using digital thermometer. Dissolved oxygen of water was calculated following/ NIH (1987-1988) and electrical conductivity was determined following method given by Jackson 1962. The levels of calcium, magnesium, chloride and bicarbonate were assessed titrimetically (Jackson 1962a, b, c, d).

**Table 1: Land types present in various localities.**

| S. No. | Localities | Land types |
|---|---|---|
| **1.** | Shahpur | Small water bodies 20%, upland, agriculture area covering 60% of the area, human settlements 20% |
| **2.** | Tanda Bhagmal | Few water bodies 10%, agriculture area 55% and human settlement 20% |
| **3.** | Lalpur | Open water bodies 30%, agriculture 50%, rest other types |
| **4.** | Nainpur | Open water bodies 50%, marshy area 20%,upland10%,agriculture 10%,human settlements 10% |
| **5.** | Indreshpur | Open water bodies 10%, agriculture 55%, rest human settlements |
| **6.** | Ranjitpur | Open water body 75% (near to Ganga bank), agriculture 25%, rest human settlement |
| **7.** | Bhikampur | Open water body 25%,agriculture area 50%, human settlements 25% |

## RESULTS AND DISCUSSION

**Fauna:** 19 species of fishes belonging to 14 genera, 09 families and 03 orders were observed during this study (Table 2). 03 species of anurans, Indian cricket frog, *Fejervarya limnocharis* (Gravenhorst), Common skittering frog, *Euphlyctis cyanophlyctis* (Schneider) and Indian bull frog, *Hoplobatrachus tigerinus* (Daudin) were observed during this study (Table 3). The Indian cricket frog has been reported to be available in small hill streams and water logged areas near paddy fields.

**Table 2: List of fishes from various localities.**

| S. No. | Species | Locality | Common Name | IUCN Status |
|---|---|---|---|---|
| | **Order Cypriniformes Family Cyprinidae** | | | |
| 1. | *Danio rerio* (Hamilton, 1822) | Ranjitpur village, Ganga River-19exs, Bann Ganga, Near Village Tanda Bhagma-01ex, Lalpur, Luxar, dist. Haridwar-01ex | Zebrafish | LC |
| 2. | *Esomus danricus* (Hamilton, 1822) | Nainpur, Luxar-06exs | Flying barb | LC |
| 3. | *Rasbora daniconius* (Hamilton, 1822) | Ranjitpur village, Ganga River-12exs, Bann Ganga, Near Village Tanda Bhagma, Nainpur, Luxar-02exs, Nainpur, Luxar-02exs | Blackline rasbora | LC |
| 4. | *Puntius chola* (Hamilton, 1822) | Ranjitpur village, Ganga River-01ex, Nainpur, Luxar-12exs | Chola barb | LC |
| 5. | *Puntius sophore* (Hamilton, 1822) | Bann Ganga near Village Shahpur, Sitakhera-03exs, Nainpur, Luxar-01ex | Spot fin swamp barb | LC |
| 6. | *Puntius ticto* (Hamilton, 1822) | Bann Ganga near Village Shahpur, Sitakhera-05exs, Nainpur-02exs | Ticto barb | LC |
| 7. | *Laubuca laubuca* (Hamilton, 1822) | Ranjitpur village, Ganga River -07exs | Indian glass-barb | LC |

| S. No. | Species | Locality | Common Name | IUCN Status |
|---|---|---|---|---|
| | | **Order Cypriniformes**<br>**Family Nemacheilidae** | | |
| 8. | *Acanthocobitis botia* (Hamilton, 1822) | Nainpur, Luxar-01ex | Loach | LC |
| | | **Family Cobitidae** | | |
| 9. | *Lepidocephalichthys guntea* (Hamilton, 1822) | Bann Ganga, Near Village Tanda Bhagma-01ex, Nainpur, Luxar-16exs | Loach | LC |
| | | **Order Siluriformes**<br>**Family Siluridae** | | |
| 10. | *Ompok pabda* (Hamilton, 1822) | Shahpur (Haridwar and Around)-01ex | Pabada Catfish | NT |
| | | **Family Erethistidae** | | |
| 11. | *Hara jerdoni* (Day,1870) | Nainpur, Luxar, dist. Haridwar-02exs | Sylhet hara | |
| | | **Order Perciformes**<br>**Family Nandidae** | | |
| 12. | *Nandus nandus* (Hamilton, 1822) | Ranjitpur village, Ganga River-01ex, Bann Ganga, Near Village Tanda Bhagma-03exs, Nainpur, Luxar-03exs | Mottled Nandus | LC |
| | | **Family Badidae** | | |
| 13. | *Badis badis* (Hamilton, 1822) | Nainpur, Luxar-01ex | Dwarf chameleon fish | LC |
| | | **Family Osphronemidae** | | |
| 14. | *Trichogaster fasciata* Bloch & Schneider, 1801 | Bann Ganga near Village Shahpur, Sitakhera-09exs, Bann Ganga, Near Village Tanda Bhagma-21ex, Nainpur- 02exs, Shahpur(Haridwar and Around)-01ex, Nainpur, Luxar-01ex | Striped Gourami | LC |
| 15. | *Trichogaster chuna* (Hamilton, 1822) | Ranjitpur village, Ganga River-01ex, Bann Ganga, Near Village Tanda Bhagma, Dist. Haridwar-08exs, Nainpur (Haridwar and around)-01ex | Sunset Gourami | LC |
| 16. | *Trichogaster lalius* (Hamilton, 1822) | Nainpur, Luxar-01ex, Lalpur, Luxar, dist. Haridwar-03exs | Dwarf Gourami | LC |
| | | **Family Channidae** | | |
| 17. | *Channa punctata* (Bloch, 1793) | Ranjitpur village, Ganga River (Haridwar)-01ex, Bann Ganga near Village Shahpur, Sitakhera, dist. Haridwar-01ex, Nainpur (Haridwar and around)-02exs, Nainpur, Luxar-21exs | Spotted Snakehead | LC |
| | | **Family Mastacembelidae** | | |
| 18. | *Macrognathus pancalus* Hamilton, 1822 | Ranjitpur village, Ganga River (Haridwar)-01ex, Bann Ganga near Village Shahpur, Sitakhera, dist. Haridwar-01ex**,** Nainpur, Luxar-01ex | Striped Spiny eel | LC |

**Table 3: Amphibian from the various localities of Study area.**

| S. No. | Species | Locality | Common Names | IUCN status |
|---|---|---|---|---|
| **Order: Anura** Fischer von Waldheim<br>**Family Dicroglossidae Anderson**<br>**Sub-Family Dicroglossinae Anderson** | | | | |
| 1. | *Fejervarya limnocharis*(Gravenhorst) | Nainpur-05exs | Alpine cricket frog | LC |
| **Family Dicroglossidae Anderson**<br>**Sub-Family Dicroglossinae Anderson** | | | | |
| 2. | *Euphlyctis cyanophlyctis* (Schneider) | Nainpur, Ranjitpur, Lalpur-15exs | Common Skittering frog | LC |
| 3. | *Hoplobatrachus tigerinus* (Daudin) | Nainpur, Bhikampur-03exs | Indian bull frog | LC |

The population of the species is denser in eastern parts of the district Dehradun (Ray, 1998). *Euphlyctis cyanophlyctis* (Schneider) was the most common anuran recorded from the area. It can tolerate considerable amount of contamination and organic pollution in temporary water pools (Ray, 1998). Five species of freshwater turtles; *Lissemys punctata andersonii* (Webb), *Pangshura tecta* (Gray), *Pangshura tentoria circumdata* (Gray), *Morenia petersi* (Anderson) and Marsh crocodile (*Crocodylus palustris* Lesson) were observed (Table 4). *Lissemys punctata andersonii* and *Pangshura tecta* are listed under Schedule-I of the Wildlife (Protection) Act, 1972, and *Pangshura tentoria circumdata* and *Morenia petersi* are a new distributional records for Uttarakhand state (Bahuguna 2009, Bahuguna 2010). Rawat and Pandav, 2006 have reported three species; *Geoclemys hamiltonii*, *Kachuga kachuga* and *Lissemys punctata* from these wetlands and all are Scheduled-I species under Wildlife (Protection) Act, 1972. The crocodiles were reported to often enter the human settlements near Laksar in Ajitpur area. The distribution of crocodiles in Uttarakhand is restricted to Corbett Tiger Reserve and Baanganga wetlands.

**Table 4: List of species of freshwater turtles from various localities.**

| S. No. | Species | Locality | Common Names | IUCN status |
|---|---|---|---|---|
| **Order Testudines**<br>**Family: Geoemydidae** | | | | |
| 1. | *Pangshura tecta* (Gray) | Shahpur, Tanda Bhagmal, Lalpur, Nainpur, Indreshpur, Ranjitpur, | Indian roofed turtle | Schedule- I |
| **Family Dicroglossidae Anderson**<br>**Sub-Family Dicroglossinae Anderson** | | | | |
| 2. | *Pangshura tentoria circumdata* (Gray) | Ranjitpur, Shahpur | Circled Indian tent turtle | Not listed |
| 3. | *Morenia petersi* (Anderson) | Bhikampur | Indian eyed turtle | Not listed |
| **Family: Trionychidae** | | | | |
| 4. | *Lissemys punctata andersonii* (Webb) | Tanda Bhagmal, Lalpur, Nainpur, Ranjitpur | Indian flap shelled turtle | Schedule- I |

**Physico-Chemical Parameters:**

**Temperature**: Mean surface temperature of the various water bodies ranged from 25º to 30º C during 2008 and 2009 (at 12.00 hrs- 12.30 hrs). The highest ambient temperature (39°C) was recorded during May and June. The increase in temperature in water leads to speeding up of chemical reactions and reduced solubility of gases (Hem 1989, NIH 1987-1988).

Continuous depletion of ground water reservoirs and deterioration of quality in Haridwar is reported by Rao & Kumar (2002). The increase in temperature in the area must be due to recent spate of urbanization, increased vehicular pollution, regular incoming of pilgrims to Haridwar and ever increasing population in Haridwar. This increase in temperature can deteriorate the conditions of some of the water bodies (2-3 meters long, Nainpur) harboring the important aquatic, and semi aquatic fauna.

**pH and electrical conductivity** : The pH recorded in the present study (Table 5) varied from 7.02 to 8.14 (in Lalpur water body near to Stone crusher unit). The range of pH for freshwater was within the permissible limit of BIS 10500 (1991). Electrical conductivity of water corresponds to the total concentration of dissolved compounds (electrolyte). It was noted to be varying from 0.191 to 0.588 ds/m. Highest has been noted to be in water bodies near to human settlements.

**Dissolved oxygen**: Dissolved oxygen varied from 3 to 4 mg/l in the present study. DO for healthy water has been recommended to be >6 mg/l by BIS 1991(Table 5). The value of dissolved oxygen in the present study varied from 3 to 4 mg /l. Oxygen plays a vital role to regulate the metabolic processes and is indicator of aquatic productivity. For average, good productivity dissolved oxygen should have concentration >5 mg/l (http://www.water-research.net/index.php/dissovled-oxygen-in-waterand). Thus, the D.O. recorded is less for the survival of the fish.

**Table 5: Water analysis of different localities covered during survey (April 2008- Sep. 2009).**

| S. No. | Localities | Mean Atmospheric temp (in ºC) (12 am to 12.30 pm) | Mean Water surface temperature (in ºC) (12 am to 12.30 pm) | pH Mean ± SD | EC(in ds/m) Mean ± SD | Dissolved oxygen (DO) in ppm Mean ± SD |
|---|---|---|---|---|---|---|
| | | Sd: not recommended | Sd: not recommended | Sd: pH 6.5 to 8.5 | Sd: EC not recommended | Sd: DO >6 ppm |
| 1. | Shahpur (in May) | 39 | 31 | 7.02 ±0.0 | 0.588±0.0 | 4±0.01 |
| 2. | Tanda Bhagmal (in May) | 39 | 30 | 7.65±0.0 | 0.528±0.0 | 3±0.01 |
| 3. | Lalpur (near to Stone crusher)(in June) | 39 | 31 | 8.14±0.1 | 0.465±0.1 | 3±0.1 |
| 4. | Nainpur (large open water body) (in July) | 38 | 32 | 7.26±0.0 | 0.257±0.01 | 4±0.01 |
| 5. | Nainpur (large open water body) (in July) | 38 | 30 | 7.35±0.2 | 0.288±0.0 | 4±0.01 |
| 6. | Shahpur (in Aug) | 34 | 30 | 7.75±0.0 | 0.324±0.01 | 3±0.02 |
| 7. | Lalpur (in June) | 39 | 30 | 7.31±0.0 | 0.203±0.0 | 4±0.02 |
| 8. | Ranjitpur (near to Ganga) (in Sep) | 32 | 25 | 7.03±0.0 | 0.191±0.0 | 4±0.02 |

Sd: Standard value as recommended by BIS 10500 (Bureau of Indian Standards) 1991: (Source: www.bis.org.in)

**Calcium**: In the present study, Calcium concentration from all localities ranged from 24-76 mg/l, highest Nainpur *i.e.* 64 mg/l, whereas for Lalpur it was 48 mg/l (Table 6). Calcium concentrations in natural waters are typically less than 15 mg/l (NIH 1987-88). For waters associated with carbonate rich rocks, level may reach 30-100mg/l. Cremation sites near Nainpur and stone crusher facility Lalpur area and intense human activities near Shahpur might have led to increased level of calcium in the water sample. It has been reported that acidic rainwater can increase the leaching of calcium from soil (Hem 1989, NIH. 1987-1988).

**Magnesium**: In the present study, the magnesium concentration ranged from 12.0 to 48 mg/l, which is within the range of natural conditions. Natural levels of magnesium in freshwater may range from 1 to 100 mg/l. Magnesium occurs in many organo metallic compounds and in organic matter since it is an essential element for living organisms. Although magnesium is used in many industrial processes these contribute relatively little to the total magnesium in surface waters (EIFAC 1964-90, ISO 1984, Hem 1989, WHO 1984a, 1984b).

**Carbonate**: Carbonate concentration in water ranged from 6 to 18 mg/l, it was noted to be nil at Nainpur and Tada Bhagmal localities (Table 6). Carbonate is uncommon in natural surface waters because they rarely exceed pH 9, whereas the groundwater can be more alkaline and may have concentrations of carbonate up to 10 mg $l^{-}$.

**Table 6: Chemical parameters of water analyzed.**

| S.No | Samples | Calcium (ppm) Mean±SD | Magnesium (ppm) Mean ± SD | Chloride (ppm) Mean ± SD | Carbonate (ppm) Mean ± SD | Bicarbonate (ppm) Mean ± SD |
|---|---|---|---|---|---|---|
| | | SR 15ppm (Ref NIH 1987-88) | SR 1-100ppm (Ref Hem 1989, WHO 1984a, 1984b) | SR <10ppm (Ref APHA 1989; CEC 1976) | SR <10ppm (Ref. WHO 1984a,1984b) | SR < 500ppm (Ref WHO 1984a, 1984b) |
| 1. | Shahpur | 76± 0.01 | 40.8 ± 0.0 | 63.9± 0.02 | 18± 0.1 | 335.5± 0.2 |
| 2. | Tanda Bhagmal | 68± 0.0 | 12.0± 0.0 | 71.0± 0.1 | nil | 164.7± 0.1 |
| 3. | Lalpur (near to Sone crusher)(in June) | 48± 0.01 | 33.6± 0.0 | 63.9± 0.0 | 15± 0.0 | 329.4± 0.2 |
| 4. | Nainpur (large open water body) (in July) | 24± 0.0 | 31.2± 0.1 | 63.9± 0.2 | nil | 134.2± 0.0 |
| 5. | Nainpur (large open water body) (in July) | 64± 0.1 | 12.0± 0.2 | 56.81± 0.1 | 18± 0.1 | 231.8± 0.01 |
| 6. | Shahpur (in Aug) | 44± 0.0 | 48.0± 0.01 | 78.1± 0.02 | 15± 0.01 | 311.1± 0.01 |
| 7. | Lalpur (in June) | 40± 0.01 | 26.4± 0.01 | 78.1± 0.01 | 12± 0.01 | 231.8± 0.01 |
| 8. | Ranjitpur (near to Ganga) (in Sep) | 28± 0.1 | 24.0± 0.2 | 78.1± 0.02 | 6.0± 0.01 | 164.7± 0.01 |

Bicarbonate concentration in surface water is usually less than 500 mg/l (WHO 1984a, 1984b). In the present study it was noted to be within the range and was the dominating anion present in surface water (Table 6).

**Chloride**: In the present observations chloride concentration was noted to be very high *i.e.* of the 56.8 to 78.1 mg/l. In freshwater, chloride concentrations are usually lower than 10 mg/l and sometimes less than 2 mg/l (APHA 1989, Hem 1989). Higher concentrations can occur near sewage and other waste outlets, irrigation drains, salt water intrusions, in arid areas and in wet coastal lines. In the present study, it seemed to be mainly through irrigation drains and waste outlets. As chloride is frequently associated with sewage, it is often incorporated into assessments as an indication of possible faecal contamination or as a measure of the extent of the dispersion of sewage discharge in water bodies (APHA 1989; Bestemyanov and Krotov, 1985; CEC 1976). The chloride level (56.8 to 78.1 mg/l) was noted to be too high depicting that the water might be leading towards eutrophication (CEC 1976, Jairam 1999).

**Threats:**

(i) Human activities in the area like cleaning cattle's, taking bath and discharge of remains of human cremation in small water bodies were affecting the health of the water as revealed by physical and chemical analysis of water. The increase in ambient atmospheric temperature that resulted in the low level of water in many small water bodies causing mortality of fishes and other aquatic fauna as observed during the surveys.

(ii) Agriculture practices around the area were affecting the water level in remnant habitats as the drainage through water pumps were done and still going on to increase the land area and for irrigation purpose. The upland and moist shores of the study area were noted to be utilized for agriculture.

(iii) The area was also exploited to collect stone for stone crusher unit present in the area. Bhupathy and Chaudhury 1995, Sharma 1998, Rao 1998 also reported that the activities like sand mining, agriculture, reclamation of wetlands and riparian areas, alternation of rivers for irrigation and generation of hydroelectric power, pollution, siltation, eutrophication and intensive fishing have been reported to cause the killing of turtles, affecting their nesting and reproduction in large scale.

(iv) The local enquiries revealed the presence of channel full of water till 1980 in the same locality meeting Ganga, thus called Baanganga. The construction of barrages/ dam on Ganga led to decrease in the water level in the channel, thus produced different land categories. However the localities near Baanganga (Haridwar) were surveyed by Adhikari (2008) and Kumar (2007) for the study of vegetation types and fish fauna.

They reported that the study area harbored many islands, varying in shape and size, which remained underwater during the rainy season and provided a good habitat to various plant taxa, birds (resident as well as migratory) and animals mainly Swamp deer, *Cervus duvauceli duvauceli* Cuvier, a critically endangered species and Hog deer, *Axis porcinus* (Zimmermann).

(v) Local enquiry revealed that the people from outside were coming to the area and asking for particular species of freshwater turtles for medicine. Illegal trade of freshwater turtles is a global problem, involving many of the developing countries. There is a demand of turtles in China, Singapore and Hong Kong markets. In India, the illegal trade of turtles is going on and the most common routes are from Kanpur to Kolkata market. Uttarakhand State earlier rich in biodiversity of turtles but recently the population of turtles has now been found to be restricted (Husain and Ray 1995), thus indicating threats to the population of turtles and tortoises in the State. There is an urgent need for the management to conserve the habitat and the species.

Therefore, it is concluded that water bodies in Baanganga wetlands of Haridwar, Uttarakhand are not in healthy conditions due to various anthropogenic conditions. Available oxygen, adequate nutrients and absence of toxic chemicals are essential factors for growth and reproduction for aquatic and semi-aquatic fauna. In the present study increasing atmospheric temperature, increased pH in some water bodies, low oxygen in water, high level of chloride ions were noted to be harmful for the habitat of aquatic and semi aquatic fauna still thriving in the area. Many scheduled species were found to be present in the area including fishes, amphibians, turtles and, crocodile, indicating the importance of the area. Low level of water during summer and increased pressure due to anthropogenic activities were noted to be increasing the threat to their survival and make them easy target of poaching.

**Management plan for the area**:

1. The water body in Nainpur locality can be a good habitat for aquatic and semi aquatic fauna after implementation of some management measures like: removal of weeds, pumping air, shifting cremation ground and involvement of local people for management of habitat, reintroduction of aquatic-semi aquatic fauna from dying habitat to environment of Nainpur.
2. Afforestation programmes around the area should be initiated to improve the habitat and to control the rising temperature.
3. Strong actions are required to conserve the threatened and endangered species as some of them may reach the threshold of critical endangerment.
4. Involvement of local people: generate awareness among local community about the importance of fauna residing in the area; involve them in reintroduction programmes, afforestation programme. Local people and turtle trappers should be involved in various surveys to get information of illegal trade.

## REFERENCES


Allen-Diaz, B., R. D. Jackson, K. W. Tate, and L. G. Oates. (2004). *California Agriculture*, **58**(3): 144-148.

Adhikari, B.S. & U.M.M. Babu (2008). Floral diversity of Baanganga Wetland, Uttarakhand, India. *Check List* **4**(3): 279–290.

APHA. (1989). *Standard Methods for the examination of water and wastewater*. 17th edition, American Public Health Association, Washington DC. : 1268 .

Bahuguna, A. (2010). New distribution record of *Morenia petersii*, *Herpetological review*, **41**(2): 242.

Bahuguna, A. (2010). Reptilia, *Fauna of Uttarakhand*, State Fauna Series, **18** (1) Director, Zoological Survey of India. : 445-503.

Bestemyanov, G.P. & Ju. G. Krotov (1985). Maximum Allowable Concentration of Chemicals in the Environment. Khimiya, Leningard, (In Russia)

Bhupathy, S. & B.C. Choudhury (1995). Status, distribution and conservation of the Travancore tortoise, *Indotestudo forstenii* in Western Ghats . *J. Bombay Nat. His.* **92**: 16-21.

Bureau of India Standard<http://www.robtex.com/gw/www.bis.org.in.htm/

CEC (Commission of European Communities) (1976). Council Directive of 18 July 1978 on the quality of fresh waters needing protection or improvement in order to support fish life (78/659/EEC). *Official journal* L/222,1-10.

CFH/MCBT (2006). Conservation Action Plan for Endangered Freshwater Turtles and Tortoises of India. Madras Crocodile Bank Trust, Tamil Nadu, South India.

Das, I. (1985). *Indian turtles: A field guide*, World Wildlife Fund- India, Oxford University Press, Calcutta,India.119 pp.

Das, I. (2002). A photographic guide to snakes and other reptiles of India. New Holland Publishers (UK) Ltd, Garfield House, 86-88 Edgware Road, London W2 2EA,UK.144pp.

Devli, L.G. & B.M. Sharma (2004). Physico chemical analysis of water samples in fresh ponds of Canchipur, Manipur. In: *Water pollution Assessment and Management* Daya Publishing House Delhi-110035, **18**: 271-275.

EIFAC (European Inland Fisheries Advisory Commission) (1964-90). Working Party on Water Quality Criteria for European Freshwater Fish. Water Quality Criteria for European Freshwater Fish, EIFAC Technical Paper Series (various tides), Food and Agriculture Organization of the United Nations, Rome.

Hem, J.D. (1989). *Study and Interpretation of the Chemical Characteristics of Natural Waters*. Water Supply Paper, 2254, 3rd edition, U.S. Geological Survey, Washington D.C. 263pp.

Husain, A. & P. Ray (1995). Reptilia, Himalayan Ecosystem Series: *Fauna of Western Himalaya*, Part I, Uttar Pradesh. 159-167.

ISO (1984). *Water quality determination of the sum of calcium and magnesium-EDTA titrimetric method*. *International Standard* ISO 6059-1984 (E), First edition 1984-06-01, International Organization for Standardization.

Jackson, M.L. (1962a). *Soil chemical analysis*. Pub: Constable and Co. Ltd. London : 1-498.

Jackson, M.L. (1962b). Soluble salt analysis for soils and water, pp234-241. In : Jackson, M.L.(ed). *Soil chemical analysis.* Pub: Constable and co. Ltd.: 234-242.

Jackson, M.L. (1962c). Dissolved carbonate & bicarbonate determination, pp 260-271, In: Jackson, M.L.(ed). *Soil chemical analysis*; Pub: Constable and co. Ltd.

Jackson, M.L. (1962d). Chloride determination.. In : Jackson, M.L. (ed). *Soil chemical analysis*; Pub: Constable and co. Ltd.

Jackson, M.L. (1962e) Elemental analysis of mineral, colloids, soils, minerals and rocks: Potassium, sodium, calcium and magnesium determination. In: Jackson, M.L. (ed.) *Soil chemical analysis*; Pub: Constable and co. Ltd. , 285-291.

Jairam, K.C. (1999). *Freshwater fishes of The Indian Region*, Narender publication house, Delhi, 551pp.

Moll, E.O. (1985). Freshwater turtles, *Sanctuary Asia* **5**, (1).

Murthy, T.S.N. & R.S. Pillai (1986). Turtles and tortoises. In : Ed. T. C. Majupuria *Wildlife wealth of India.*, Tecpress Service, L.P., Thailand.

NIH. (1987-1988). *Physico-chemical Analysis of Water and Wastewater*. National Institute of Hydrology, Roorkee- 247667 (UP), India.

Rao, R. J. (1990). Ecological relationships among freshwater turtles in the National Chambal Sanctuary. Study report mimeo. Wildlife Institute of India. 212pp.

Rao, M.S. & R. B. Kumar (2002). *Ground water conditions in Haridwar district*: *Geological Society of India*, **29**: 114-126.

Rao, R.J. (1985). Management of crocodiles and turtles in Wetland Sanctuaries of India, *Tiger paper*, **12** (4).

Rao, R.J. (1998). Status of crocodiles and freshwater turtles in the Chambal river and Ganga river: a comparative analysis, *Cobra* **33**, 31-34.

Rao, R.J. (2001). Biological resources of Ganga River, India, *Herpetobiologia*, **458**: 159-168.

Rawat, G.S. & B. Pandav (2006). An ecological assessment of Baan Ganga Wetland, Uttaranchal-a report from Wildlife Institute of India, submitted to Forest Department, Govt. of Uttaranchal: 1-83.

Ray, P. (1998). Systematic studies on the Amphibian fauna of the district Dehradun, Uttar Pradesh, India, *Memoirs*. (Published-Director Zoological Survey of India), **18** (3) IV+102pp

Sharma, R.C. (1998). *Fauna of India-Reptilia* (*Testudines and Crocodilia*).I, XVI+1-196 (Published-Director, ZSI, Kolkata).

Shiva Kumar, K. (2007). Diversity, conservation and sustainable use of fish resources of Banganga wetland, Uttarakhand, India. *Indian Forester* **133**(10): 1373-1380.

SNB, DehraDun (2009) *Ganga ke anchal mein magarmach in Rashtriya Sahara*, pp3.

WHO (1984a). *Guidelines for Drinking –Water Quality*, 1. Recommendations. World Health Organization, Geneva, 130pp.

WHO (1884b). *Guidelines for Drinking– Water Quality*. 2. Health Criteria and Other Supporting Information. World Health Organization, Geneva.