Starter Document – Biodiversity

ESTIMATING ENVIRONMENTAL FLOWS THROUGH BIODIVERSITY ASSESSMENT IN RIVER RAMGANGA

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1. INTRODUCTION

Assessing biodiversity is vital to determine the status of biological diversity at one or more ecological levels and determine temporal and spatial changes. The information thus collected provides guiding principle for decisions on how to manage biological diversity in terms of production and conservation. Rivers are dynamic ecosystems and the many facets of its flow regime, e.g. magnitude, timing, frequency, duration, and rate of change influence its structure and function[1]. Life history strategies of aquatic species are known to have evolved in response to natural flow variability[2]. Over half of the world's major river systems are presently affected by flow regulation[3], and climate change is predicted to further modify historical flow patterns in many rivers. The impacts of river alterations manifest themselves in the imperilment of aquatic biota[2] and in the reduced ability of rivers to provide valued ecosystem services upon which humans depend[4]. Information on hydraulic habitat requirements of major vertebrate and invertebrate fauna for River Ramganga is lacking. Hence, the present study is an attempt to elucidate the distribution pattern and habitat preference of the *selected* fauna vis-à-vis environmental flows.

2. SURVEY STRETCH

Ramganga is the first major tributary joining the Ganga. This spring-fed river rises at an altitude of about 3,110 m in the southern slopes of Dudhatoli (middle Himalayas) in the Uttarakhand state. Initially the river flows in south westerly direction for about 32 Km before it turns right and flows successively through Almora and Garhwal districts of Uttarakhand for about 112 Km. The length of the Ramganga River from its source to the confluence with the Ganga is approximately 596 km. During its course, the river flows through mountainous terrain and has a number of falls and rapids in the districts of Chamoli, Nanital, Almora and Pauri Garwal in Uttarakhand. Ramganga forms the lifeline of Corbett National Park near Ramnagar of Nainital district from where it descends upon the plains. The river enters the plains at Kalagarh near the border of the Garhwal district, where the famous Kalagarh dam has been constructed. 26 km downstream of Kalagarh, a barrage at Harewali diverts most of the water for irrigation and feed the main Ganga at Tighri ghat. Beyond Kalagarh, the river flows in a south-easterly direction passing through 14 districts of Uttar Pradesh including Bijnore, J.P Nagar, Moradabad, Bareilly, Sahajanpur and Hardoi. Finally it joins the Ganga on its left bank near Kannauj (Tera Ghat of the Hardoi district).

The intensive survey stretch comprised of *ca.* 500 km river stretch; from Bhikiasain in Uttarakhand state till Dabri in Uttar Pradesh state (Figure 1).

Figure 1. Map of survey stretch, from Bhikiasain in Uttarakhand state till Dabri in Uttar Pradesh state.

3. METHODOLOGY

Field surveys were conducted during summer (14-27 May 2014), monsoon (17-26 August 2014), and winter (11-15 December 2014, and 11-16 January 2015). Data were collected from eight pre-identified sites/sampling stations (Table 1).

Sampling for invertebrate fauna was conducted using a kick D-frame net and lifting of stones in the upland stretch of the river while sieving of soft substratum with the help of test sieve (0.05mm mesh size) and Ekmanndrage in low land section of the river. Sub-surface velocity was measured using a current velocity meter. Samples were taken from margin of the river to the maximum approachable depth. These were preserved in 90% Ethanol for laboratory analysis and were identified with the help of standard keys[5,6] and Functional Feeding Group/s (FFG) were determined following reference guides[7,8,9].

Information on fish fauna was collected through experimental fishing using cast net. At each site sampling was conducted for 1 hour. For each catch; species diversity, abundance, size, and weight were recorded. A sample of each species was preserved in 10% Formaldehyde Sol. Habitat features such as; river width, river depth, river velocity, and substratum were recorded. For additional information fish market surveys were also conducted and interviews with local fishermen were held. Fish species were identified as per standard identification guides[10]. All species names adhere to Fish Base[11].

To document relative abundance and distribution of higher vertebrates (Dolphin, Otter, Turtle, and Crocodilians) information was collected largely through informal interviews with locals (in particular fishermen). Standard field guides were consulted and displayed to the respondent to identify the species. For habitat preference by Otters random plots were laid in 2km survey stretch (centre being the CS point) to record data on riverbank substrate (availability/use); river characteristics (width, depth and flow); escape cover and prey availability.

Table 1. Sampling sites pre-identified along the survey stretch in River Ramganga.

Sampling station	Latitude N	Longitude E	Altitude (m asl)
Bhikiasain (s 1)	29° 63' 49"	79° 26' 667"	777
Marchula (s 2)	29° 73' 112"	79° 25' 46" E	560
$^{d}/_{s}$ Afzalgarh Barrage (s 3)	29°49 ' 069"	78° 75' 552"	320
$^{d}/_{s}$ Hareoli Barrage (s 4)	29° 41' 924"	78°61' 932"	230
Agvaanpur (s 5)	28° 56' 55.8"	78°43' 26.1"	192
Katghar (s 6)	28°49' 22.1"	78°47 '58.6"	189
Chaubari (s 7)	28°17' 14.9	79°22' 10.3"	160
Dabri (s 8)	27°29' 51.9	79°41' 45.8	138

4. OBSERVATIONS

4.1 Habitat characteristics

At Bhikiasain and upstream *ca*. 5km at Naulla (29°44'50.3"N; 79°14'43.7"E) river is generally fast flowing with riffles, runs, and pools. Over the seasons and across the year, the river width ranged between 10-50m and avg. depth ranged 0.50m-1.80m. In stream substrate particle size varied with varying depths. Boulders with occasional sandy patches dominated deep waters (>60cm), while cobble and pebble dominated shallow water (≤10cm). Riverbanks are composed of boulders and sand rocks with no or occasional marginal vegetation. The site is rich in fish fauna.

Downstream at Marchula the river generally flows fast with riffles, runs and deep pools. Over the seasons and across the year, the river width ranged between 10-40m; avg. depth ranged 0.60m-2.50m. In-stream substrate particle size varied with varying depths. Boulders with occasional sandy patches dominated deep water (>40cm), while combinations of cobble, pebble and sand; and cobble, pebble, sand and boulders dominated shallow waters (≤30cm). Right bank is composed of boulders and slanting sand rock ridge with no or occasional marginal vegetation, while the left bank is largely sandy and flat. Otter occurrence is reported, and the species uses boulders and natural rock crevices as denning sites. Sand bank are used as basking sites by both Otters and Crocodilians.

$^{d}/_{s}$ Afzalgarh barrage the zone was recorded as a high water level fluctuation zone and the landscape is agriculturally dominated. Initially the river is generally shallow and fast flowing; while downstream at ca. 40km the river is deep. Over the seasons and across the year, river width ranged 30-70m; and avg. depth ranged 0.50m-2.25m. Riffles are found along with fine sand substratum. The river bank substrate composition is largely cobble and pebble, but the composition changes abruptly from cobble and boulder to sand within a 5km stretch from downstream of the barrage. Riverbanks are with no or occasional marginal vegetation. Species like Otters and Crocodilians often disperse into this zone as it lies abutting a PA. The site is disturbed with heavy anthropogenic pressure.

$^{d}/_{S}$ Hareoli barrage the river is moderately fast and the wetted channel is often reduced due to low flow. Over the seasons and across the year, river width ranged between 10-25m; and avg. depth ranged 0.50m-1.50m. Riverbanks are largely sandy and both banks remain exposed. The dominant in-stream substrate particle recorded was sand and silt. Land-use is agriculture and also the wetland areas and the river stretch is given on lease to fishermen.

At Agwaanpur the water current is fast. Over the seasons and across the year, river width ranged between 30-40m; and avg. depth recorded was 1.5m. The substratum composition is mainly clay and silt but is unstable due to retreating flood waters. Land-use is agriculture.

Katghar was heavily polluted due to sewage and other anthropogenic activities particularly washing and dyeing of clothes. The wetted channel is generally reduced due to low flow. Over the seasons and across the year, river width ranged between 10-80m; and avg. depth ranged 0.50m-1.50m. Micro-habitats recorded are run, and pools where the riverbanks are steep. The dominant substrate particle composition recorded is sand and silt.

Chaubari was flood receded site and the main channel of the river was fragmented due to generation of sand bars in the mid-channel. Clay and silt composition were the dominant substratum. River width ranged between 15-60m; and avg. depth ranged 0.50m-1.10m. Extensive Palage (river-bed farming) was recorded.

At Dabri, water current recorded was fast. Over the seasons and across the year, river width ranged between 80-150m; and avg. depth recorded was 4m. Dominant substrate particle composition recorded was clay and silt. The landscape is agriculturally dominated and anthropogenic activities like fishing, coin collection, cattle bathing and washing clothes were recorded.

4.2 Species distribution, abundance and habitat preference

4.2.1 Invertebrate fauna

The benthic invertebrates are sensitive to changes in flow and habitat conditions. In stream hydraulic parameters such as velocity and depth relate to the dimensions of the stream channel, reduced flows can affect population densities and community compositions of many aquatic organism including mussels, shrimps, fishes and macro-invertebrates[12]. Since the invertebrates differ in their environmental tolerances and requirements and any loss of habitat area or alteration of food resources from decreased flow can influence organism behavior and biotic interactions, they can thus be considered as impending candidates for flow related studies.

The historic information about invertebrate fauna is available for the upper reaches of the Western Ramganga[13]. This information is largely in the form of check list irrespective to habitat and substratum. Few studies have also been conducted on habitat preferences/requirements of the macro-invertebrate fauna in rivers similar to Ramganga [14,15,16]. There are no studies conducted in the lower stretch of the Ramganga in Plains. The historic information was segregated as per the habitat and substratum requirement of the invertebrate fauna. Presently, the taxa are indicated with their abundance in each season. The taxonomic composition represented with (>10%) share in present condition have been considered. The taxa with very low abundance (<3%) suggests its rarity and is indicated by an astrix sign (*). † indicates the emergence of the insects from larvae and pupa. This occurs in the monsoon therefore the adults will be available during monsoon period and individuals may also be present as eggs and pupa.

The suggested desired condition of the River Ramganga in different seasons and at different stations is based on the functional feeding group of the taxa. River Ramganga is a 3rd order stream in the upper stretch, hence it is functionally heterotrophic and lower stretch is of 4th to 5th order, hence functionally autotrophic. The kind of desired taxa will depend on the type of substratum and habitat available at that particular station. For the development of the heterotrophic condition of the river in the upper stretch, the taxa should be functionally Shredder/Predator/Collector. Similarly for autotrophic condition in lower stretch of the river the desired taxa should be Grazer type.

Observations recorded during summer sampling (May 2014)

At each location the benthic macro-invertebrate fauna comprised of individuals that were mostly:

(i). Common and occurred in high - medium counts.
(ii). Rare and present only at specific stations, and occurred in low counts.

Upland stretch: common and abundant taxa

Bhikiasain

Hydropsychidae (Filter-feeders) and Psephenidae (Grazers) were recorded at all observed depths (Fig. 2). Hydropsychidae counts were high (12-60 ind/ft^2) in medium shallow & deep habitats (19-48 cm) and displayed an apparent preference for a wider range of habitats at various depths (10-48 cm). Psephenidae

showed a distributional trend similar to Hydropsychidae (counts ranging 10-25 ind/ft^{2}in medium-shallow & deep habitats). Perlodidae (Predator), highest numbers of individuals (8-10 ind/ft^2) were observed at 10-19cm depth; Heptageniidae (Grazer), highest numbers of individuals (21 ind/ft^2) were observed at 19cm. Baetidae, Tabanidae (Gathering-collectors) and Simulidae (Filter-feeders) were present in good numbers but only across some habitats. The Baetids (7-28 ind/ft^2) seemed to prefer shallower habitats (10-19cm deep), the Tabanids (10 ind/ft^2) were recorded at a depth of 30cm while, the Simuliids (27 ind/ft^2) recorded at a depth of 22cm. Siphlonuridae (Gathering-collector) were recorded in low numbers (1-6ind/ft^2) across habitats 22-30cm deep (Fig. 2).

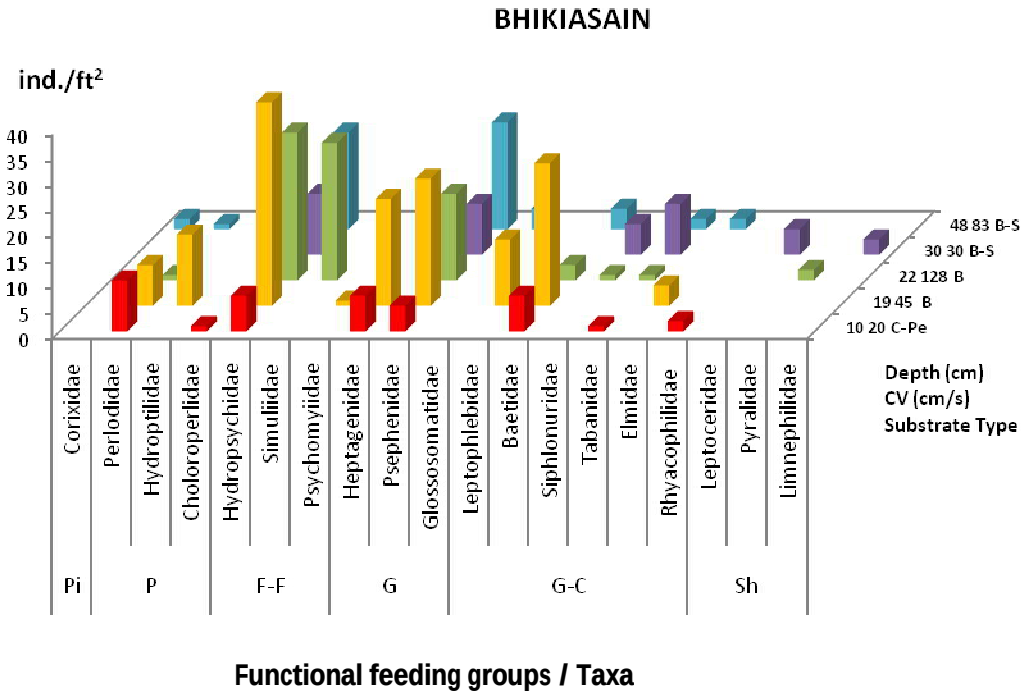

Figure 2. Counts (Ind /ft^2) and functional feeding groups of macro-invertebrate fauna at different depths, current velocities and substrate type at Bhikiasain. **Acronym:** B-Boulder, C-Cobble, Pe-Pebble, P-Predator, F-F-Filtering Feeder, G-Grazer, Sh-Shredder, G-C Gathering collector.

Marchula

Hydropsychidae (Filter-feeder) and Perlodidae (Predator) were recorded at all observed depths (Fig. 3). Hydropsychidae (2-25 ind/ft^2) and Perlodidae (10-15 ind/ft^2) counts were higher in shallow and medium shallow habitats (13-30cm) in Cobble to Cobble-Pebble dominated substrate. Grazers Heptagenidae (6-10 ind/ft^2) and Psephenidae (8-20 ind/ft^2) were present in good numbers in shallow and medium shallow habitats (13-30cm) in Cobble to Cobble-Pebble dominated substrate.

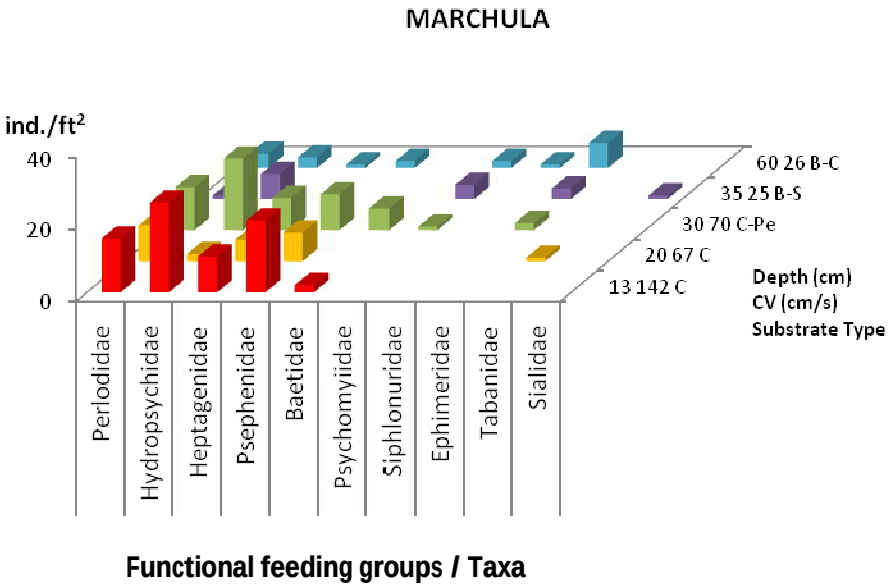

Figure 3. Counts (Ind/ft^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Marchula. **Acronym:** B-Boulder, C-Cobble, Pe-Pebble, P-Predator, F-F-Filtering Feeder, G- Grazer, Sh-Shredder, G-C Gathering Collector.

$^{d}/_{s}$ *Afzalgarh barrage*

No macro-invertebrate fauna was recorded immediately downstream (0.5-2Km stretch) of the barrage due to recent releases from the barrage (as indicated by the Irrigation Department Officials), highlighting fresh inundation and constrained colonization. Corixidae (Water-boatmen) was the only observed Taxa, inhabiting shallow (20-25cm) habitat in sandy substrate with rooted vegetation; downstream (3km downstream of Gurudwara site).

Upland stretch: rare taxa with very low counts

Bhikiasain

Choloroperlidae (1 ind/ft^2), Psychomyiidae (1 ind/ft^2) and Rhyacophilidae (2 ind/ft^2) were found in shallow habitats (10cm) in Cobble-Pebble substrate, while Glossomatidae (4 ind/ft^2) and Limnephilidae (3 ind/ft^2) were found in deeper habitats (48cm) in boulder-sand substrate. Out of these a single Taxa i.e. Pyralidae (2 ind/ft^2) was observed from medium-shallow habitat (22cm) in boulder substrate; Corixidae (2 ind/ft^2) and Leptoceridae (5 ind/ft^2) were found in 48cm deep habitat in boulder-sand substrate) (Fig. 2).

Marchula

Sialidae (1 ind/ft^2) and Ephemeridae (2-7 ind/ft^2) were found in medium shallow to deeper habitats (30-60cm) in substrate varying from Cobble-Pebble Mix to Boulder-Cobble). Siphlonuridae (1 ind/ft^2) and

Tabanidae (1 ind/ft^2) were recorded from different habitats, wherein Siphlonuridae was found in deep water (60cm) in boulder-cobble substrate and Tabanidae was found in 20cm deep habitat in cobble-pebble substrate (Fig. 3).

Lowland stretch: common and abundant taxa

Hareoli barrage

Caenidae (Gathering-Collector) and Corixidae (Piercer) were recorded at all the sampled depths. Caenide (2-8 ind/ft^2) and Corixidae (3-7 ind/ft^2) counts were higher in shallow habitats (7-13cm) deep in Sand and Rooted vegetation (Fig. 4). Gomphidae (Predator) were present at all observed depths (7-17cm) but in low numbers, about 1-3 ind/ft^2.

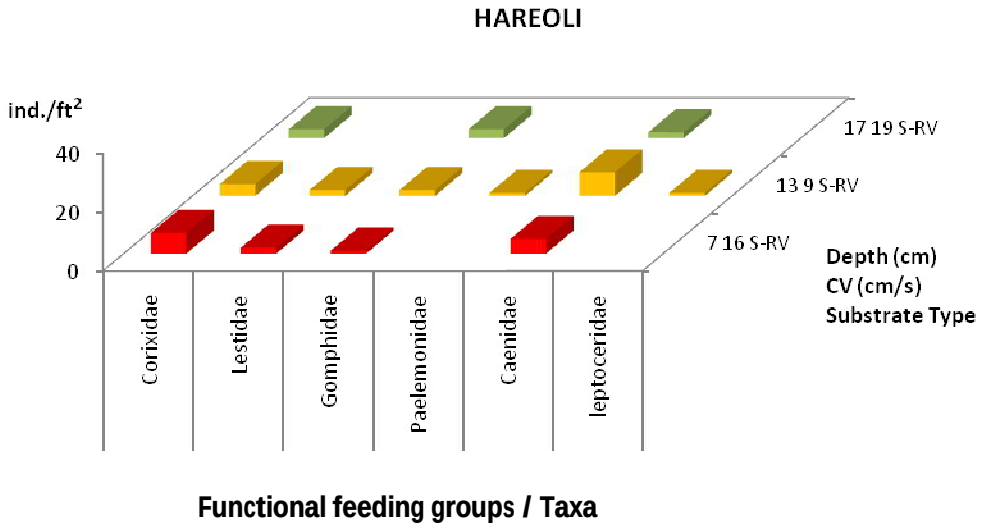

Figure 4. Counts (Ind/ft^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Hareoli. **Acronym:** B-Boulder, C-Cobble, Pe-Pebble, Pi-Piercer, P-Predator, F-F-Filtering Feeder, G- Grazer, Sh-Shredder, G-C Gathering Collector.

Agwanpur

Corixidae (Piercer), Lymnaedae (Grazer) and Gomphidae (Predator) were abundant. The substrate remained similar at all the observed depths. Lymanedae was exclusively found at Agwanpur and showed a narrow range of depth preference (3-7cm), Corixidae (12 ind /ft^2) and Gomphidae (9 ind /ft^2) were found in shallow habitats, 3-7cm deep (Fig. 5).

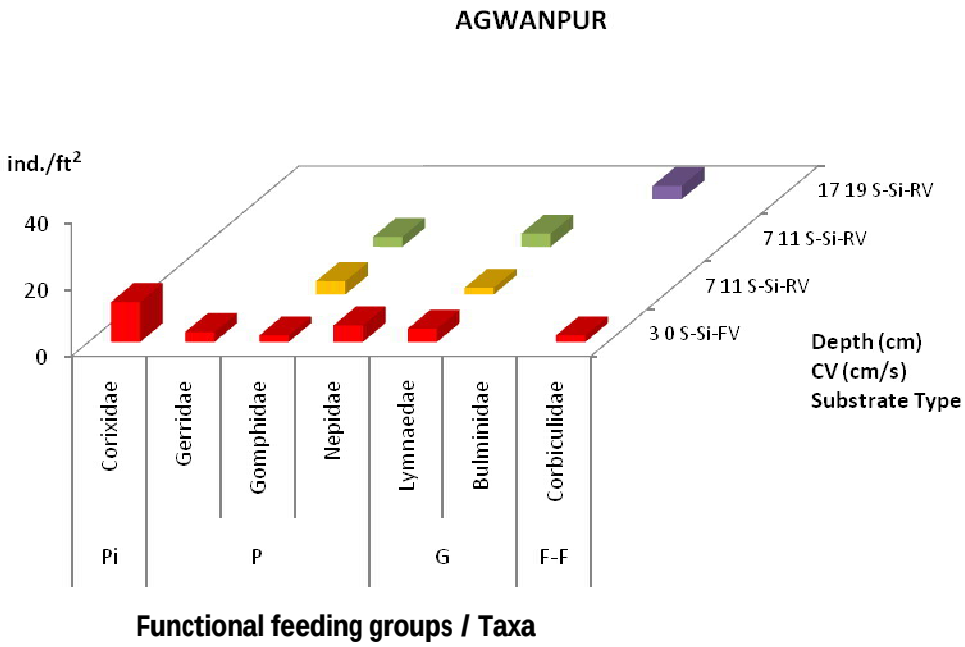

Figure 5. Counts (Ind/ft^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Agwanpur. **Acronym:** B-Boulder, C-cobble, Pe-Pebble, Pi-Piercers P-Predator, F-F-Filtering Feeder, G- Grazer, Sh-Shredder, G-C Gathering collector.

Katghar

This is heavily polluted sampling stretch. Red Chironomids were found in shallow habitat dominant in sand and rooted vegetation substrate.

Chaubari

Corixidae (Piercer), Chironomidae (Gathering-Collector), Gomphidae (Predator) and Letpceridae (Shredder) were abundant at this site. Corixidae (20 ind/ft^2) were restricted at depth of 10cm with sand as the dominant substrate, Chironomidae (20-49 ind/ft^2) were found in depth varying from 10-30cm with sand as the dominant substrate, Gomphidae (10 ind/ft^2) were restricted at depth of 10cm with sand as the dominant substrate and Leptoceridae (2-20 ind/ft^2) were observed in depth ranging between 5-30cm with sand as the dominant substrate (Fig. 6).

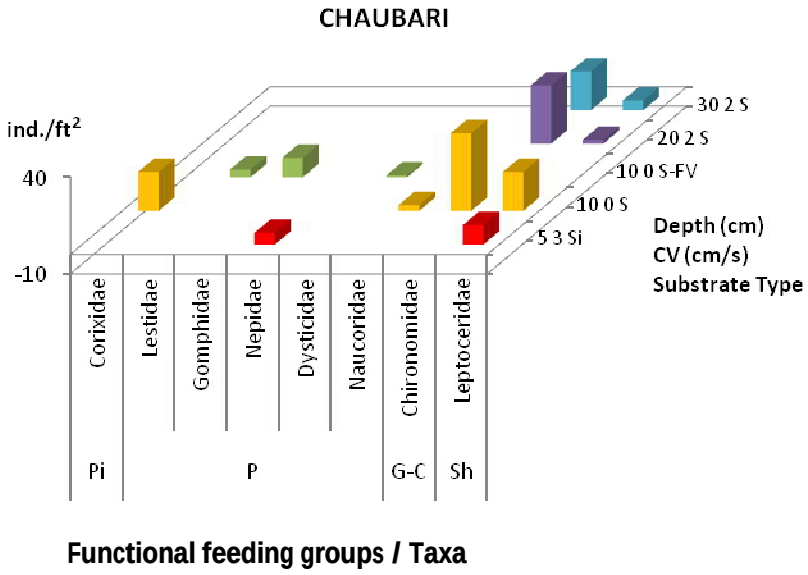

Figure 6. Counts (Ind/ft^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Chaubari. **Acronym:** B-Boulder, C-Cobble, Pe-Pebble, Pi-Piercer, P-Predator, F-F-Filtering Feeder, G-Grazer, Sh-Shredder, G-C Gathering Collector.

Dabri

Only Chironomidae were found (9-10 ind/ft^2) and dominated the fauna at all the observed depths (Fig. 7).

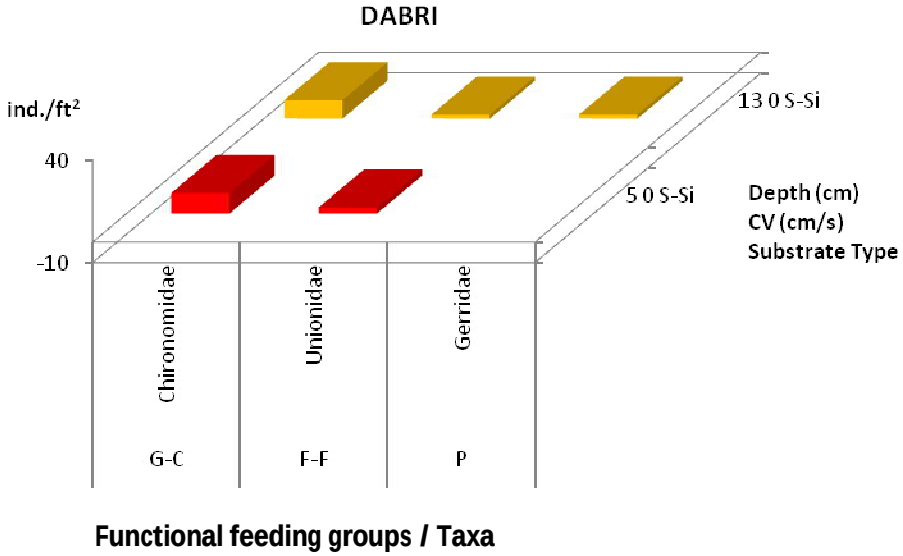

Figure 7. Counts (Ind/ft^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Dabri. **Acronym:** B-Boulder, C-Cobble, Pe-Pebble, Pi-Piercer, P-Predator, F-F-Filtering Feeder, G-Grazer, Sh-Shredder, G-C Gathering Collector.

Lowland stretch: rare taxa with very low counts

Hareoli

Predators like Lestidae and Palaemonidae were present in low numbers along with Leptoceridae (Shredder). Lestidae (4 ind/ft^2) were found in shallow depths (7-13cm), Leptoceridae (1 ind/ft^2) and Palaemonidae (1 ind/ft^2) were also found in shallow depths of 13cm. Substrate recorded was sandy at all the observed depths (Fig. 4).

Agwanpur

Predators like Gerridae, Nepidae and Grazers like Bulminidae, and Filter Feeders like Corbiculidae were found in least numbers. Bulminids were found in 17cm depth while the rest of the Taxa were found in shallow depth of 3cm. Corbiculidae and Bulminidae were exclusive to Agwanpur site (Fig. 5).

Chaubari

Predators like Naucoridae and Dysticidae were found to be exclusive to Chaubari site but were found in low numbers. Both these Taxa were found at similar depths of 10cm and in Sand as the dominant substrate (Fig. 6).

Dabri

Predators like Gerridae and Filter Feeders like Unionidae were found in low numbers. Unionidae (2-3 ind/ ft^2) were exclusive at Dabri site and were recorded from all observed depths (5-13cm) while Gerridae (2 ind/ft^2) were found in 13cm deep habitat. Substrate was predominantly Sand- Silt Mix in this stretch (Fig. 7).

Observations recorded during monsoon sampling (August 2014)

At each location the benthic macro-invertebrate fauna comprised of individuals that were mostly:

(i). Common and occurred in high - medium counts.
(ii). Rare and present only at specific stations, and occurred in low counts.

Upland stretch: common and abundant taxa

Bhikiasain

Invertebrate sample were collected from riffles (depths-10-17 cm), runs (more than 27 cm deep) and pools. Among these habitats total 13 taxa (family) were recorded. Elmidae was most abundant taxa at 10, 17 cm depth with cobble –pebble substratum and at 60 cm with boulder substratum. Similarly, Baetidae was abundant at 35 cm depth with cobble - boulder, at 45 cm with boulder and at 55 cm with boulder – sand substratum (Figure 8).

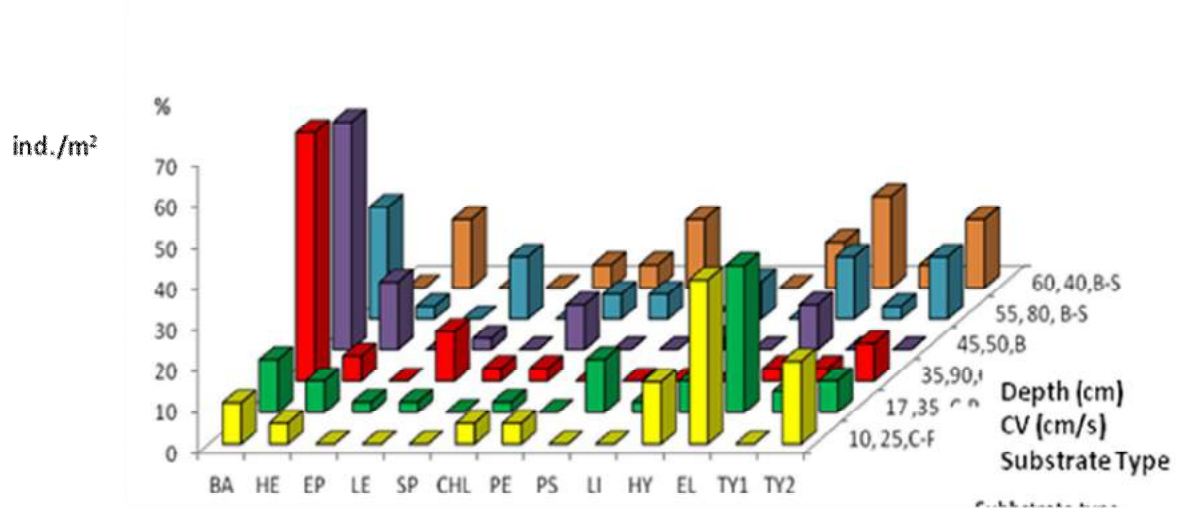

Figure 8. Counts (Ind/m^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Bhikiasain. **Acronym:** B-Boulder, C-Cobble, Pe-Pebble, Pi-Piercer, P-Predator, F-F-Filtering Feeder, G- Grazer, Sh-Shredder, G-C Gathering Collector, BA-Baetidae, HE-Heptageniidae, EP-Ephemerillidae, LE-Leptophlebidae, SP-Siphlonuridae, CHL-Chloroperlidae, PE–Perlodidae, LI–Limnephilidae, HY–Hydropsychidae, EL–Elmidae, Hemiptera-TY1, TY2.

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Marchula

Riffle and run habitats were sampled at this location. The riffle habitat was observed at 7, 10 and 15 cm depth below the suspension bridge, while runs were observed at rest of the sampling depth located at 900 U/S m of the riffle. Total 14 taxa were recorded. Out of these Hydropsychidae was most abundant taxa at 10, 15, 20, 25 and 35 cm depth associated with their preferred combination of substrate cobble-pebble-sand, cobble -sand -pebble and boulder –sand while Baetidae was abundant at 35 (high flow condition) and 44 cm depth associated with substrate type boulder and boulder-sand. However, both Hydropsychidae and Baetidae were equally dominant at 7 cm depth associated with substrate type cobble-pebble-sand (Figure 9).

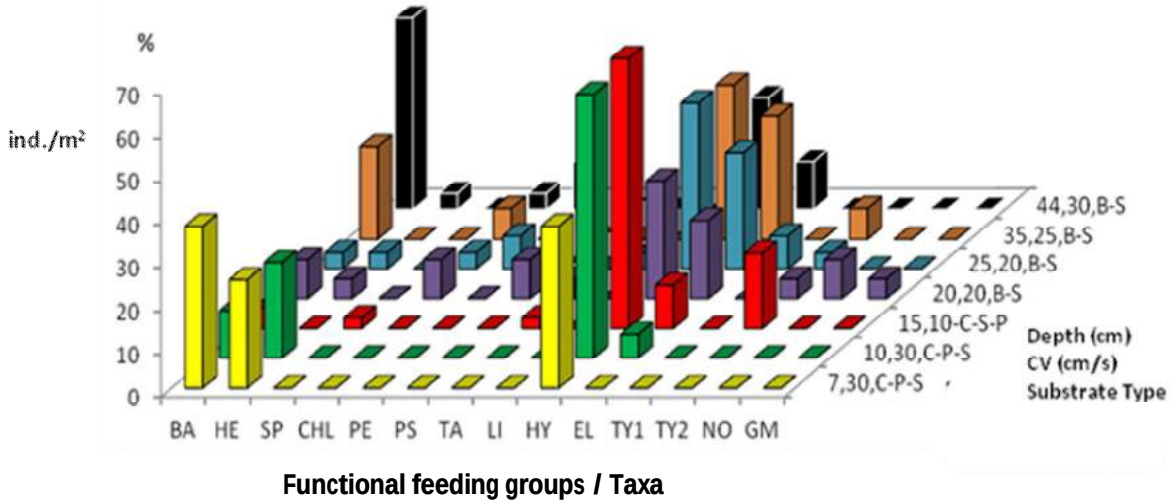

Figure 9. Counts (Ind/m^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Marchula. **Acronym:** TA – Tabanidae, NO- Notonectidae, GM –Gomphidae. The remaining acronyms are same as Figure 8.

$^{d}/_{s}$ Afzalgarh barrage

Riffle habitat is found along with substratum with fine sand particles. No macro invertebrate were recorded at this location due to flood which make the substratum unstable and inhibit colonization of invertebrate fauna.

Upland stretch: rare taxa with very low counts

Besides the flow indicator taxa (based on abundance), some taxa are common at all depth but with low abundance and some are rare and present only one condition. The taxa which have low abundance and rare will be affected first when the volume of the water will reduce.

Bhikiasain

Heptageniidae and Chloroperlidae were present at all the sampled locations with low abundance and Leptophlebiidae, Limnephlebidae, Perlidae, Hydropsychiidae and Hemiptera were present at most of the sampled locations with low abundance. However, Psychomidae and Ephemerillidae were the rarer and found on cobble–pebble substrate and 17 cm deep riffle habitat at 35 cms^{-1} velocity. Sphilonuridae was present on boulder substratum, but in two different depths (35 and 60 cm) and velocities (90 and 40 cms^{-1})

Marchula

Heptageniidae was present at all the sampled locations but in low abundance. However, Chloroperlidae, Elmidae and Hemiptera (TY2) were present in most of the samples with low abundance. Notonectidae - Gomphidae and Limnephilidae –Hemiptera (TY1) were the rare taxa present on boulder – sand. They preferred 20 cm depth, 20 cms^{-1} velocity and 20 cm depth, 25 cms^{-1} velocity, respectively. Siphlonuridae was restricted taxa present on only 15 cm depth, 10 cm s^{-1} and cobble –sand –pebble substratum. Similarly, Psychomyiidae was restricted to 20 cm depth, 20 cm^{-1} velocity and Boulder -sand substratum and Simulidae was restricted to 35 cm depth, 50 cm $^{-1}$ velocity and boulder substratum. Perlidae was restricted to only two different depths (25 and 44 cm) and velocities (20 and 30 cm^{-1}) and boulder–sand substratum. Tabanidae was also restricted to two different depths (15 and 20 cm), velocities (10 and 20 cm^{-1}) and substratum type (cobble–sand-pebble and boulder–sand).

Lowland stretch: common and abundant taxa

$^{d}/_{s}$ Hareoli barrage

The water volume was greatly reduced (even less than that observed during the May-June visit). This situation had continued from Mid July (according to a local fisherman). Since the river had recently receded. Wetted Channel was smaller due to low flow and large sandy banks were exposed on both banks. No macroinvertebrate fauna were recorded from the active/wetted channel of the river. Only Unionidae, Corbiculidae, Lymnaedae (Molluscs) were found partially buried throughout the exposed sandy banks.

Agwanpur

Only right bank of the river was sampled. Run was the only habitat observed at right bank. The previous locations (in May sampling) were not sampled during monsoon season due to high flood. The substratum was mainly clay-silt but was unstable by retreating flood water. Only Corbiculidae, Lymnaedae, Planorbidae, Bulminidae, Thiaridae (Molluscs) were recorded from the exposed bank of the river.

Katghar

The discharge of the river was high due to flood (Figure 3). Run was the major habitat present at this site along with some pools located where the banks were steep. The samples were collected from the run habitat only. Only Chironomidae was recorded at 10 cm depth. Gerridae present striding over the water surface close to the banks.

Chaubari

This was another recently flood receded site along with clay-silt substratum. The main channel of the river was fragmented due to generation of sand bars in mid of the channel. Left bank of the river sampled with run habitat. No invertebrate fauna was recorded at this location.

Dabri

The samples were collected from the left bank 100m $^{d}/_{s}$ of central water control board gauge (CWCB). Run was the main habitat along with clay –silt substratum at this site. However, pool was also seen 200 m $^{d}/_{s}$ of CWCB gauge. Unionidae was only found in river water, however Corbiculidae and Lymnaedae (Molluscs) taxa were observed at exposed bank of the river.

Lowland stretch: rare taxa with very low counts

No such taxa were encountered in the lowland stretch.

Observations recorded during winter sampling (December 2014-January 2015)

At each location the benthic macro-invertebrate fauna comprised of individuals that were mostly:

(i). Common and occurred in high - medium counts.
(ii). Rare and present only at specific stations, and occurred in low counts.

Upland stretch: common and abundant taxa

Bhikiasain

Total 18 taxa (family) were recorded. Of these, 14 taxa were recorded from riffle habitat, 8 from rapid habitat, 13 from run habitat and 2 taxa from pool habitat. Simulidae, Hydropsychidae and Leptoceridae were most abundant taxa in the riffle habitat at 7 cm, 20 cm and 45 cm depth respectively; while Polycentropodidae was most abundant taxon at different sampling depths in the run habitat. Chironomidae and Leptoceridae were most abundant taxa in the pool and rapid habitat respectively (Figure 10).

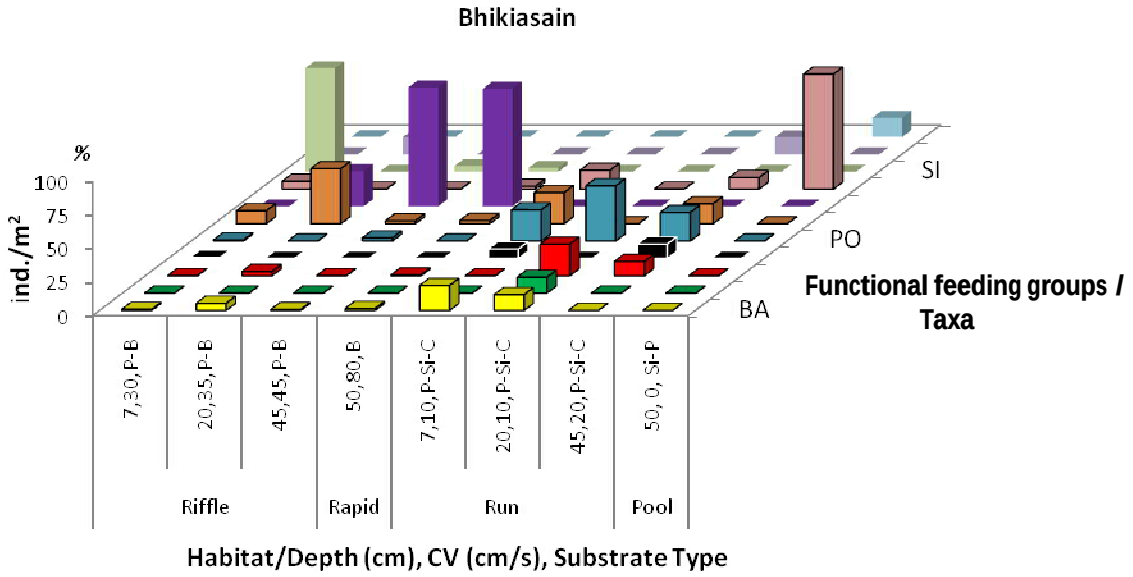

Figure 10a. Counts (Ind/m^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Bhikiasain. **Acronym:** BA-Baetidae, CA-Caenidae, LE-Leptophlebidae, HE- Heptageniidae, PO-Polycentropodidae, HY-Hydropsychidae, LP-Leptoceridae, CH-Chironomidae, SI-Simulidae, TI-Tipulidae, GLO-Glossoscolecidae, B-Boulder, C- Cobble, P-Pebble, Si- Silt.

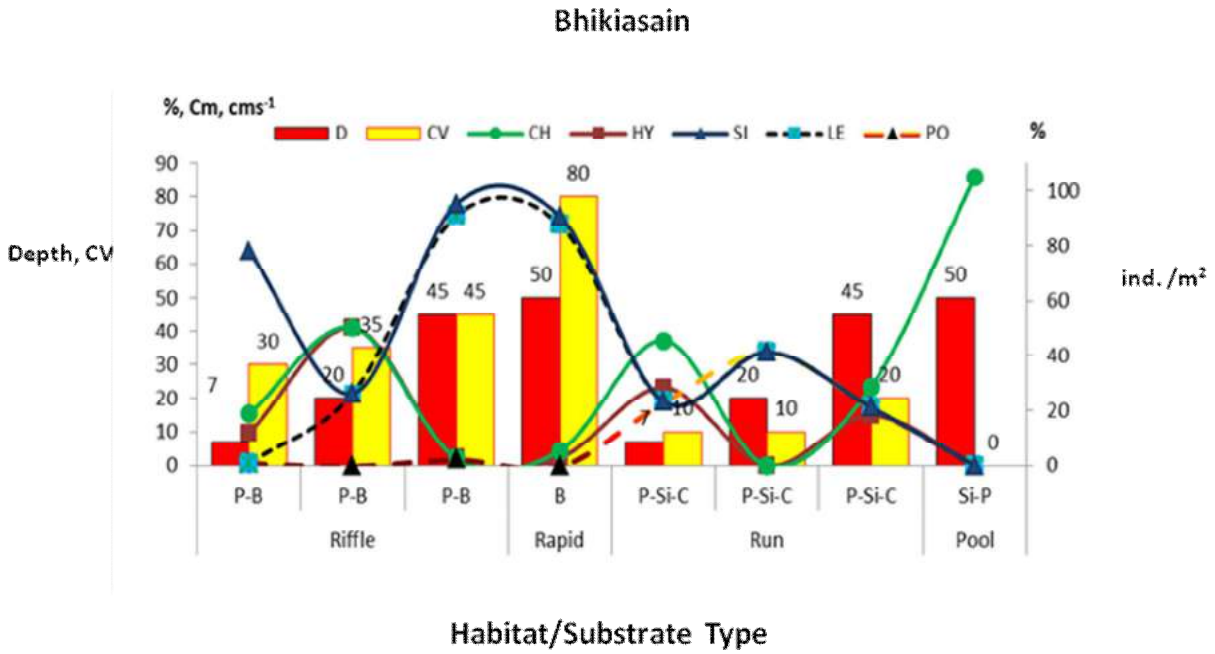

Figure 10b. At Bhikiasain, Chironimidae, Hydropsychidae, Simulidae, Leptophlebidae and Polycentropodidae were recorded to be exclusively depth and velocity sensitive taxa. **Acronym:** LE-Leptophlebidae, PO-Polycentropodidae, HY-Hydropsychidae, CH-Chironomidae, SI-Simulidae, B-Boulder, C- Cobble, P-Pebble, Si- Silt, D-Depth, CV-Current velocity.

Marchula

Total 17 taxa (family) were observed at Marchula. Out of these, 14 taxa were recorded from riffle habitat, 5 from rapid, 12 from run and one taxa from the pool habitat. Simulidae was most abundant taxon at all the depth in the riffle habitat, while Psephenidae was most abundant in the rapid habitat at 50 cm depth. Heptageniidae, Baetidae and Psephenidae were most abundant taxa in the run habitat at 7cm, 20 cm and 35 cm depth, respectively. Chironomidae was most abundant at 30 cm depth in pool habitat (Figure 11).

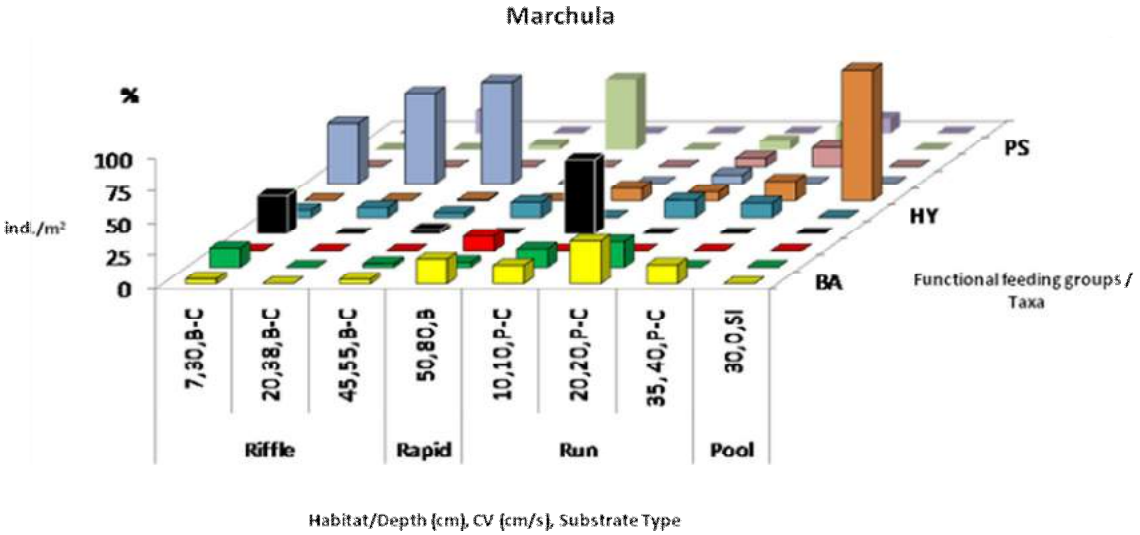

Figure 11a. Counts (Ind/m^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Bhikiasain. **Acronym:** EP-Ephemerellidae, EL-Elmidae, PS-Psephenidae, DY- Dytiscidae. Rest of the acronyms are similar as in Figure 10a.

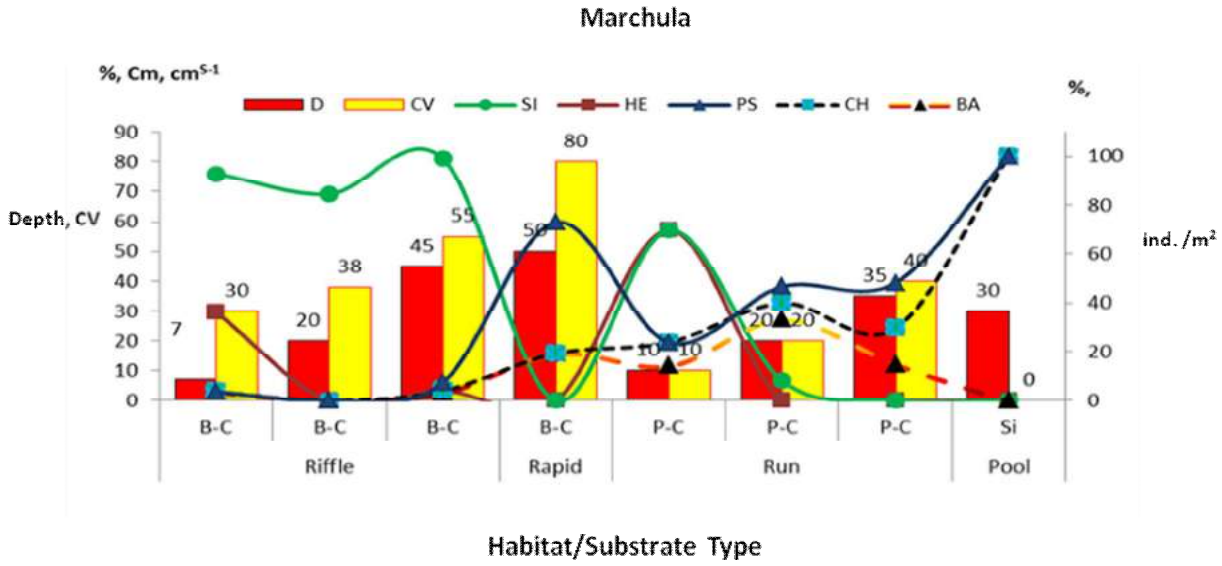

Figure 11b. At Marchula, Simulidae, Heptageniidae, Psephenidae, Chironomidae and Baetidae were recorded to be exclusively depth and velocity sensitive taxa. **Acronym:** CH-Chironomidae, SI-Simulidae, PS-Psephenidae, BA-Baetidae, HE- Heptageniidae, B-Boulder, C- Cobble, P-Pebble, Si- Silt, D-Depth, CV-Current velocity.

$^{d}/_{s}$ *Afzalgarh Barrage*

Total 7 taxa were observed at S3. Out of these, 5 taxa were recorded from riffle habitat and 3 taxa from run habitat. In the riffle habitat, Chironomidae and Anthericidae were most abundant taxa at 7cm depth and Chironomiddae was predominant at 45 cm depth. However in the riffle habitat, Corixidae was predominant at 20 cm depth. Thiaridae was most abundant taxon at 45 cm depth in the run habitat (Figure 12).

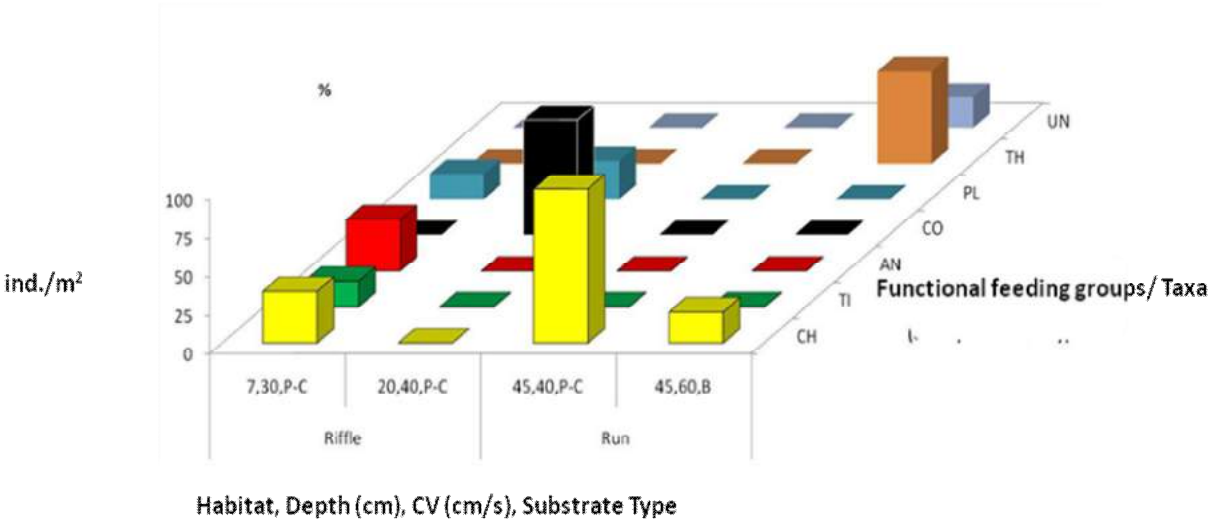

Figure 12a. Counts (Ind/m^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Afzalgarh. **Acronym:** B-Boulder, C- Cobble, P-Pebble, Si- Silt, Sd- Sand, D-Depth, CV-Current velocity, CH-Chironomidae, TI-Tipulidae, AN-Anthericidae, CO- Corixidae, PL- Planorbidae, TH- Thiaridae, UN-Unionidae.

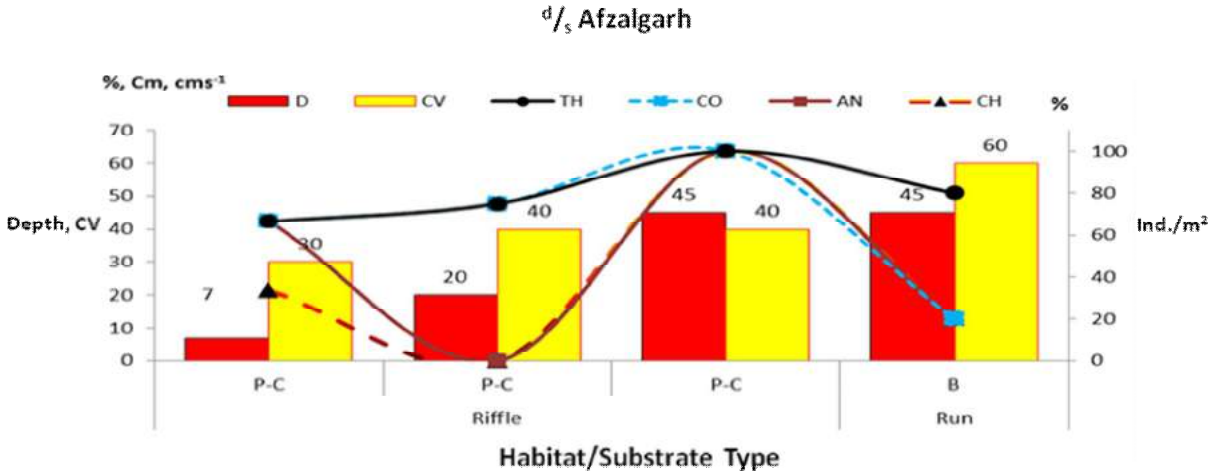

Figure 12b. At $^{d}/_{s}$ Afzalgarh, Thiaridae, Corixidae, Anthericidae and Chironomidae wererecorded to be exclusively depth and velocity sensitive taxa. **Acronym:** B-Boulder, C- Cobble, P-Pebble, Si- Silt, Sd- Sand, D-Depth, CV-Current velocity, CH-Chironomidae, AN-Anthericidae, CO- Corixidae, TH- Thiaridae.

Upland stretch: rare taxa with very low counts

Certain taxa are habitat specific and their occurrence is restricted to particular depth and flow condition. At Bhikiasain, Siphlonuridae, Heptageniidae, Psephenidae, Chironomidae and Chaobonidae were restricted at 7 cm depth while Leptophebidae, Blephariceridae and Tipulidae were restricted at 20 cm depth in the riffle habitat. Similarly, in the run habitat, Brachycentridae was restricted at 7 cm depth while Siphlonuridae, Blephariceridae and Tipulidae were restricted at 45 cm depth. In the rapid habitat Blephariceridae and Leptophebidae were recorded as critical/rare taxa. At Marchula, in the riffle habitat Dytiscidae was restricted at 20 cm depth, while Leptophlebidae, Siphlonuridae, Hydrophilidae, Chironomidae and Psephenidae were restricted at 45 cm depth. In the run habitat, Leptophlebidae was restricted at 7 cm depth, while Hydrophilidae and Simulidae were restricted at 20 cm depth and Psychomyiidae, Empidae and Dytiscidae at 45 cm depth. Caenidae was recorded as critical/rare taxa in the rapid habitat. At $^{d}/_{s}$ Afzalgarh Tipulidae and Anthericidae were recorded as critical/rare taxa being restricted at 7 cm depth in the riffle habitat.

Lowland stretch: common and abundant taxa

Hareoli barrage

Siven taxa were observed. In the riffle habitat, Chironomidae was most abundant taxa at 7 cm and 20 cm depths, while Psychodidae was only taxon present at 45 cm depth. In the pool habitat, Chironomidae was predominant taxon at 30 cm depth (Figure 13).

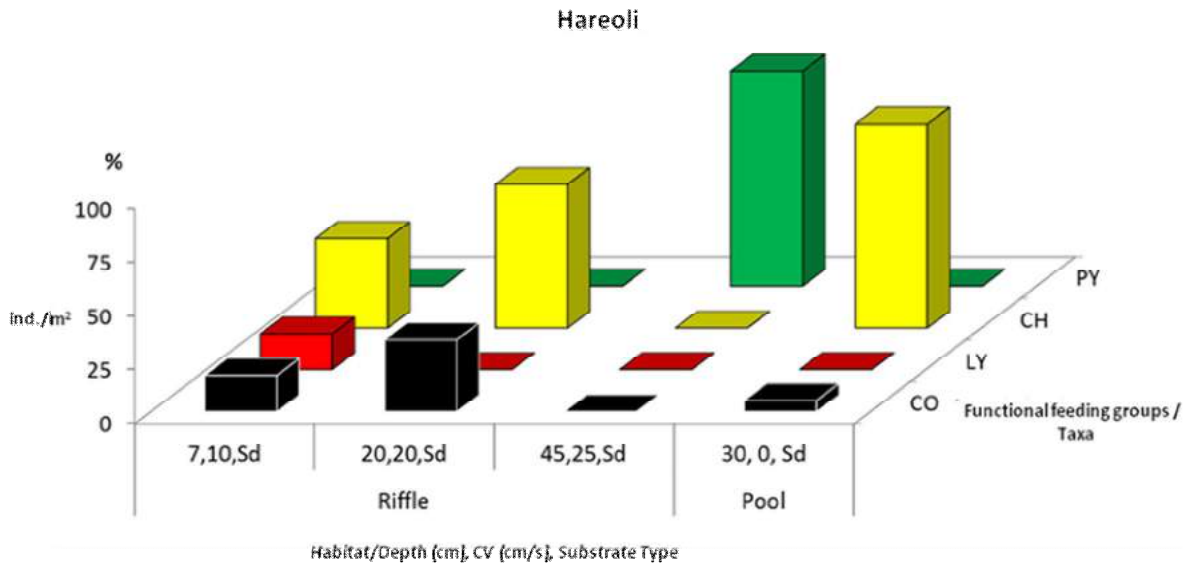

Figure 13a. Counts (Ind/m^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Hareoli barrage. **Acronym:** Sd- Sand, D-Depth, CV-Current velocity, CH-Chironomidae, CO- Corixidae, LY- Lymneadae, PY- Psychodidae.

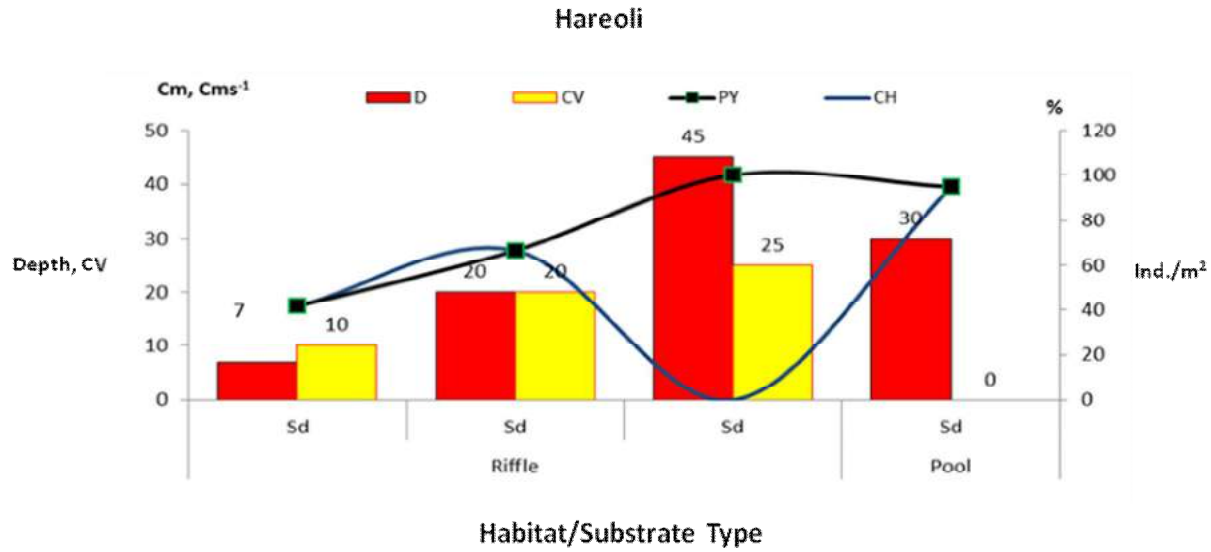

Figure 13b. At Hareoli barrage, Psychodidae and Chironomidae were recorded to be exclusively depth and velocity sensitive taxa. **Acronym:** Sd- Sand, D-Depth, CV-Current velocity, CH-Chironomidae, PY-Psychodidae.

Agwanpur

Four taxa (family) were recorded; 3 in the run and 2 in the pool habitat. Chironomidae was most abundant taxa at 7 and 35 cm depth in run habitat and 55 cm in pool, while Ceratopoginidae at 17 cm with silt –clay substratum (Figure 14).

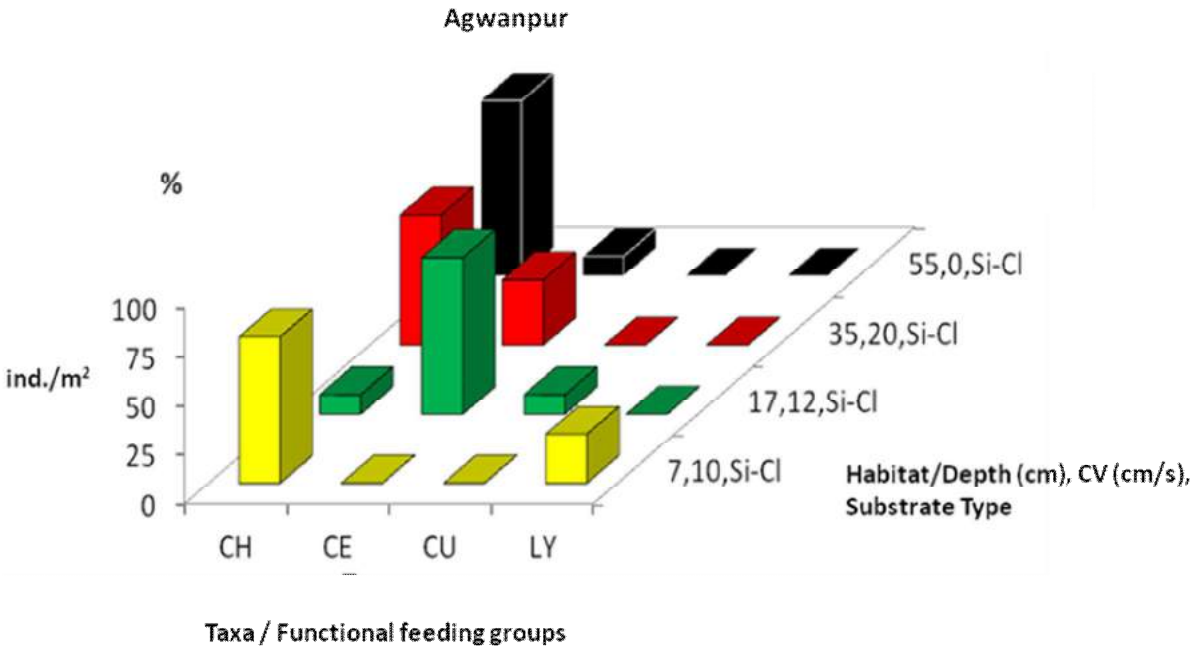

Figure 14. Counts (Ind/m^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Agwanpur. **Acronym:** D-Depth, CV-Current velocity, CH-Chironomidae,CE- Ceratopogonidae, CU-Culicidae, LY- Lymnaedae, Si-Silt, Cl-Clay.

Katghar

Four taxa (family) were recorded in the run habitat. Among these taxa, Naididae (Class-Oligochaeta) was most abundant at all sampling depths followed by Chironomidae and Tubificidae (Figure 15).

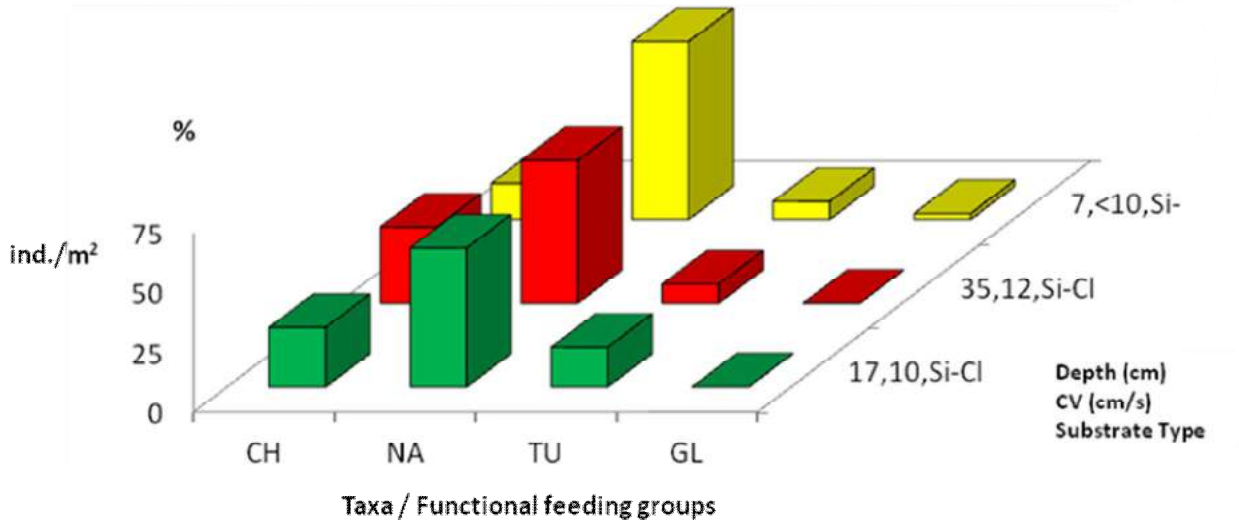

Figure 15. Counts (Ind/m^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Katghar. **Acronym:** CH-Chironomidae, NA-Naididae, GL-Glossoscolecidae, TU - Tubificidae, Si-Silt, Cl-Clay.

Chaubari

Total six taxa were recorded. Chironomidae was most abundant taxa at all the depths and their respective current velocity except 35 cm where Syrphidae was abundant (Figure 16).

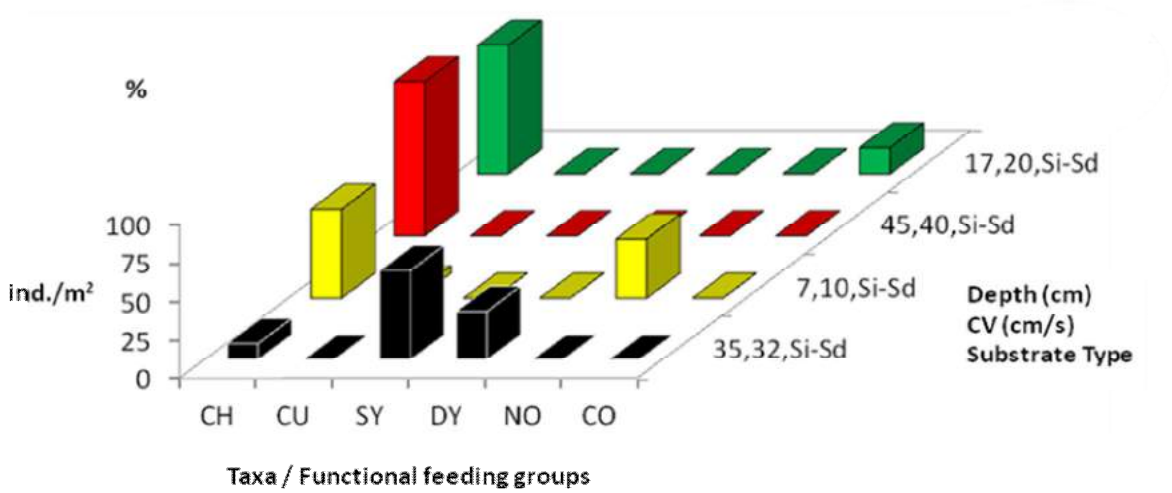

Figure 16. Counts (Ind/m^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Chaubari. **Acronym:** CH-Chironomidae, CU- Culicidae, SY- Syrphidae, DY-Dytiscidae, NO- Notonectidae, CO- Corbiculidae , Si-Silt, Sd-Sand.

Dabri

Five taxa were recorded. Chironomidae was most abundant taxa at all the depths and their respective current velocity except at 45 cm where Ceratopogonidae was abundant (Figure 17).

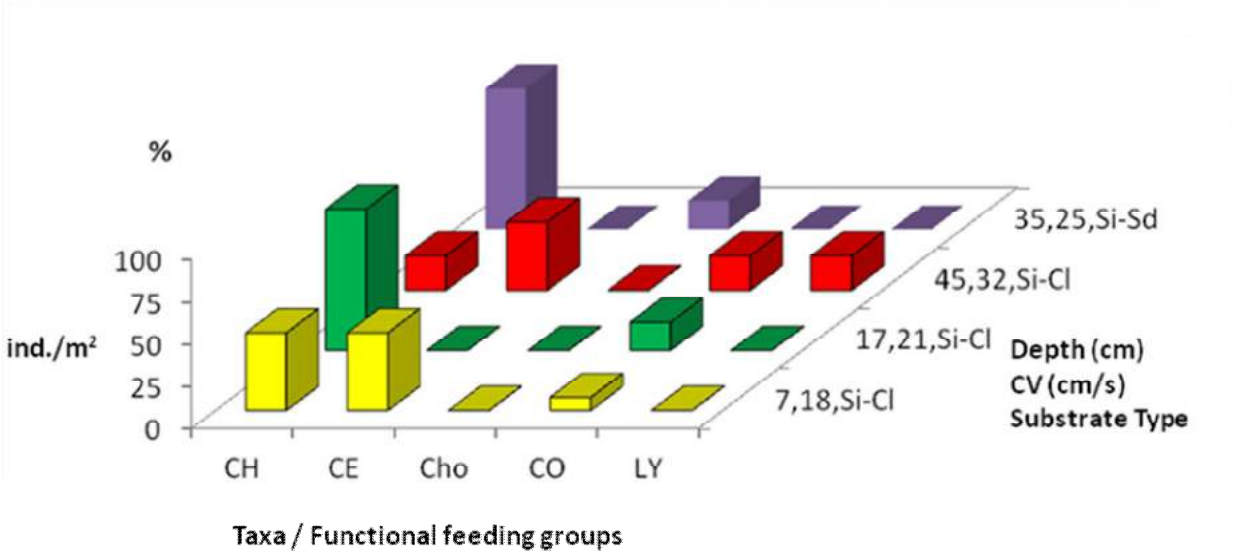

Figure 17. Counts (Ind/m^2) of macro-invertebrate fauna at different depths, current velocities and substrate type at Dabri. **Acronym:** CH-Chironomidae, CE- Ceratopogonidae, Cho- Chaoboridae, CO-Corbiculidae, , LY- Lymnaedae, Si-Silt, Cl-Clay.

Lowland stretch: rare taxa with very low counts

At Agwanpur, Lymnaedae and Culicidae were recorded as critical/rare taxa restricted to 7 cm and 17 cm depth respectively. Similarly, at Kathghar, Tubificiade was critical/rare (low count) taxa while Glossoscolecidae was restricted to 7 cm depth only. In case of Chaubari, Culiciade and Notonectidae were restricted to 7 cm depth, while Corbiculidae was restricted to 17 cm depth. Syrphidae and and Dytiscidae were restricted to 35 cm depth only. At Dabri Chaoboridae and Lymnaedae were restricted to 35 cm and 45 cm depths, respectively.

Table 2a. Record of benthic macro-invertebrate (ind/ft^2) at different depths in the upland survey stretch along River Ramganga during summer sampling.

BHIKIASAIN-AFZALGARH											
Station	**BHIKIASAIN**					**MARCHULA**					**AFZALGARH**
Depth (cm)	**10**	**19**	**22**	**30**	**48**	**13**	**20**	**30**	**35**	**60**	**25**
Families											
Perlodidae	10	8	1		1	15	10	12	1	4	
Hydropsychidae	7	60	29	12	19	25	2	20	7	3	
Baetidae	7	28	3		4	2		6			
Heptagenidae	7	21		4	1	10	6	9		1	
Hydroptilidae		14									
Rhyacophilidae	2										
Elmidae		4			2						
Psychomyiidae		1						1	4	2	
Choloroperlidae	1										
Leptophlebidae		13									
Psephenidae	5	25	17	10	21	20	8	10		2	
Siphlonuridae			1	6						1	
Leptoceridae				5							
Limnephilidae				3							
Glossosomatidae					4						
Corixidae					2						18
Tabanidae	1		1	10	2		1				
Simuliidae			27								
Lepidoptera			2								
Sialidae									1		
Ephimeridae								2	3	7	

Table 2b. Record of benthic macro-invertebrate (ind/ft^2) at different depths in the Lowland survey stretch along River Ramganga during summer sampling.

HAREOLI-DABRI																
Stations	**HAREOLI**			**AGVAANPUR**			**KT***		**CHAUBARI**				**DABRI**			
Depth(cm)	**7**	**13**	**17**	**3**	**7**	**7**	**17**	**7**	**5**	**10**	**10**	**20**	**30**	**5**	**13**
Families															
Caenidae	5	8	2												
Leptoceridae									10	20		2	5		
Corixidae	7	4	3	12						20					
Lestidae	2	2									4				
Leptoceridae		1													
Gomphidae	1	2	3								10				
Nepidae				5					6						
Lymnaedae				4	2	4									
Gomphidae				2	4	3									
Corbiculidae				2											
Bulmidae							4								
Chironomidae								25		49		30	20	10	9
Paelemonidae		1													
Naucoridae										3					
Dysticidae											1				
Unionidae														3	2
Gerridae				3											2

Table 3. Record of benthic macro-invertebrate (ind/m^2) at different depths and current velocity in the survey stretch along River Ramganga during monsoon sampling.

Station	Habitat	Substrate type	Depth (cm)	Sub-surface velocity (cms^{-1})	Flow indicator taxa	Functional Feeding Groups (FFG)
Bikhiasain	Riffle	C-P	10	25	Elmidae	Predator
	Riffle	C-P	17	35	Elmidae	-do-
	Run	C-B	35	90	Baetidae	Gathering -collector
	Run	B	45	50	Baetidae	-do-
	Run	B-S	55	80	Baetidae	-do-
	Run	B-S	60	40	Elmidae	Predator
Marchula	Riffle	C-P-S	7	30	Baetidae	Gathering -collector
	Riffle	C-P-S	10	30	Hydropsychidae	-do-
	Riffle	C-S-P	17	10	Hydropsychidae	-do-
	Riffle	B-S	20	20	Hydropsychidae	-do-
	Riffle	B-S	25	20	Hydropsychidae	-do-
	Run	B-S & B	35	25 and 50	Hydropsychidae and Baeitiade	-do-
	Run	B-S	45 cm	30	Baetidae	-do-
Katghar	Run	Cl-Si	10	<10	Chironomidae	-do-
	Run	Cl-Si	20	12	**NA**	-
	Run	Cl-Si	45	35	NA	-

Acronym: B-Boulder, C-Cobble, Cl-Clay, P-Pebble, S-Sand, Si-Silt.

Table 4a. Record of benthic macro-invertebrate (ind/m^2) at different depths and current velocity in the Upland survey stretch along River Ramganga during winter sampling.

Station	**Habitat**	**Substrate Type**	**Depth (cm)**	**Sub-surface velocity (cms^{-1})**	Depth and velocity indictor taxa	**Functional Feeding Groups (FFG)**
Bhikiasain	Riffle	P-B	7	30	Simulidae	*Collector
		P-B	20	35	Hydropsychidae, Leptoceridae	*Collector, Predators
		P-B	45	45	Leptoceridae	Predator
	Rapid	B	50	80	Leptoceridae	Predator
	Run	P-Si-C	7	10	Polycentropodidae, Hydropsychidae	Predator, *Collector
		P-Si-C	20	10	Polycentropodidae, Leptophlebidae	Predator
		P-Si-C	45	20	Polycentropodidae, Hydropsychidae	Predator *Collector
	Pool	Si-P	50	0	Chironomidae	** Collector
Marchula	Riffle	B-C	7	30	Simulidae, Heptageniidae	*Collector, Scraper
		B-C	20	38	Simulidae	*Collector
		B-C	45	55	Simulidae	*Collector
	Rapid	B	50	80	Psephenidae, Baetidae	Scraper **Collector
	Run	P-C	7	10	Heptageniidae	Scraper
		P-C	20	20	Baetidae, Caenidae	**Collector
		P-C	35	40	Psephenidae, Elmidae, Chironomidae, Baetidae	Scraper, Predator, **Collector
	Pool	Si	30	0	Chironomidae	**Collector
$^{d}/_{s}$ Afzalgarh barrage	Riffle	P-C	7	30	Chironomidae, Anthericidae	**Collector
		P-C	20	40	Corixidae	Scraper
		P-C	45	40	Chironomidae	**Collector
	Run	B	45	60	Thiaridae	Scraper

***Collector:** Filtering collectors
****Collector:** Gathering collectors

Table 4b. Record of benthic macro-invertebrate (ind/m^2) at different depths and current velocity in the Lowland survey stretch along River Ramganga during winter sampling.

Station	Habitat	Substrate Type	Depth (cm)	Sub-surface velocity (cms^{-1})	Abundant taxa	Functional Feeding Groups (FFG)
Hareoli barrage	Riffle	Sand	7	10	Chironomidae	**Collector
		Sand	20	20	Chironomidae	**Collector
		Sand	45	25	Psychodidae	**Collector
	Pool	Sand	30	0	Chironomidae	**Collector
Agwanpur	Run	Silt-Clay	7	10	Chironomidae	Gathering - collector
	Run	Silt-Clay	17	12	Ceratopongonidae	-do-
	Run	Silt-Clay	35	20	Chironomidae	-do-
	Pool	Silt-Clay	55	Nil	Chironomidae	-do-
Katghar	Run	Silt-Clay	7	<10	Naididae	Filtering Collector
	Run	Silt-Clay	17	10	Naididae	-do-
	Run	Silt-Clay	35	12	Naididae	-do-
Chaubari	Run	Silt-Clay	7	10	Chironomidae	Gathering - collector
	Run	Silt-Clay	17	20	Chironomidae	-do-
	Run	Silt-Clay	35	32	Syrphidae	-do-
	Run	Silt-Clay	45	40	Chironomidae	-do-
Dabri	Run	Silt-Clay	7	18	Chironomidae, Ceratopongonidae	-do-
	Run	Silt-Clay	17	21	Chironomidae	-do-
	Run	Silt-Clay	35	25	Chironomidae	-do-
	Run	Silt-Clay	45	32	Ceratopongonidae	-do-

***Collector:** Filtering collectors
****Collector:** Gathering collectors

Table 5. Summary: Habitat requirement (Observed/Desired) recorded for invertebrate fauna along River Ramganga during the study period (May 2014 – January 2015).

Pre-identified survey site	Habitat type along with substrate type	Invertebrate fauna						
			Present along with depth			Desired		
		Reference	Summer	Monsoon	Winter	Summer	Monsoon	Winter
Bhikiasain	Riffle; Cobble-Pebble	Perlidae, Perlodidae, Capniidae, Dysticidae, Helophoridae, Staphylinidae	Hydropsychidae-Psephinidae - Baetidae: 42.6-17-11.5 *Elmidae < Siphlonuridae	Baetidae-Elmidae: 29.3, 25 *Ephemerilidae=, Siphlonuridae= Perlodidae= Limnephilidae	Leptoceridae-Simulidae-Hydropsychidae-Tipulidae: 88.7-77.2-41.1-12.6 *Polycentropodidae> Heptageniidae	**Hetrotrophic** (Perlidae, Perlodidae, Capniidae, Dysticidae, Helophoridae, Staphylinidae	†Emergence Period (Eggs and adult)	**Hetrotrophic** (Perlidae, Perlodidae, Capniidae, Dysticidae, Helophoridae, Staphylinidae Leptoceridae-Simulidae-Hydropsychidae
	Run; Boulder-cobble	Heptageniidae, Baetidae Perlidae, Perlodidae, Capniidae	Psephenidae-Hydropsychidae :42-38 *Perlodidae	Baetidae-Elmidae: 33.3-14.9 * Siphlonuridae > Hydropsychidae	Polycentropodidae-Leptophlebidae-Hydropsychidae-Baetidae: 41.2-23.5-25.3-18.6	**Hetrotrophic** Heptagenidae, Perlidae, Capniidae	†Emergence Period (Eggs and adult)	**Hetrotrophic** Heptagenidae, Perlidae, Capniidae, Polycentropodidae, Leptophlebidae-Hydropsychidae
	Rapid	Leptoceridae, Perlidae, Perlodidae	No	No	Leptoceridae:87.7 *Simulidae>Chironomidae Baetidae	No	No taxa due to habitat loss	**Hetrotrophic** Leptoceridae, Perlidae, Perlodidae
	Pool	Chironomidae, Glossoscolecidae, Coleoptera, Hemiptera	No	No	Chironomidae-Glossoscolecidae: 85.7-14.3	No	No taxa due to habitat loss	**Hetrotrophic** Chironomidae, Glossoscolecidae, Coleoptera, Hemiptera
Marchula	Riffle; Boulder-cobble-pebble	Baetidae, Leptophlebidae, Ephemerillidae, Heptagenidae, Hydropsychidae,	Hydropsychidae-Psephenidae-Perlodidae: 31-21.9-21.9 *Psephenidae-	Hydropsychidae (47.5) *Siphlonurida= Limnephilidae= Gomphidae	Simulidae-Heptageniidae-Dytiscidae-Caenidae:77.7-29.6-16.9-14.8 *Chironomidaee	**Hetrotrophic** Baetidae, Leptophlebidae, Ephemerillidae, Heptagenidae,	†Emergence Period (Eggs and adult)	**Hetrotrophic** Baetidae, Leptophlebidae, Ephemerillidae, Hydropsychidae,

		Glossosomatidae	Ephimeridae			Glossosomatidae		Glossosomatidae Simulidae-Dytiscidae-Caenidae
Marchula	Run; Boulder	Baetidae, Caenidae, Leptophlebidae, Ephemerillidae, Limnephilidae, Stenopsychidae,	Ephemeridae - Perlodidae: 35-20 *Siphlonuridae = Heptageniidae	Baetidae: 56.8, *Heptageniidae	Heptageniidae-Baetidae-Caenidae-Psephenidae: 57-33.3-20-18.5	**Hetrotrophic** Caenidae, Leptophlebidae, Ephemerillidae, Limnephilidae, Stenopsychidae,	†Emergence Period (Eggs and adult)	**Hetrotrophic** Baetidae, Ephemerillidae, Limnephilidae, Stenopsychidae
	Rapid	Leptoceridae, Perlidae, Perlodidae	No	No	Psephenidae-Baetidae-Ephemerellidae-Hydropsychidae:53.8-19.2-11.5-11.5	No	No taxa due to habitat loss	**Hetrotrophic** Leptoceridae, Perlidae, Perlodidae, Psephenidae-Baetidae-Ephemerellidae-Hydropsychidae
	Pool	Chironomidae, Glossoscolecidae, Coleoptera, Hemiptera	No	No	Chironomidae:100	No	No taxa due to habitat loss	**Hetrotrophic** Glossoscolecidae, Coleoptera, Hemiptera
$^{d}/_{s}$ Afzalgarh	Run; Sand	Simuliidae, Tipulidae	NA	NA	Thiaridae-Chironomidae-Unionidae:60-20-20	**Hetrotrophic** Simuliidae, Tipulidae	†Emergence Period (Eggs and adult)	**Hetrotrophic** Simuliidae, Tipulidae, Chironomidae-
	Riffle	Baetidae, Simuliidae, Tipulidae	NA	NA	Chironomidae-Corixidae-Anthericidae:33.3-28.5-19	No	No taxa due to habitat loss	**Hetrotrophic** Baetidae, Simuliidae, Tipulidae Chironomidae-Corixidae-Anthericidae
$^{d}/_{s}$ Harewali	Run; Sand	Simuliidae, Tipulidae, Agrionidae, Chlorocyphidae, Calopterygidae	Caenidae - Corixidae: 36.6-34 *Paelemonidae =Leptoceridae	NA	No	**Hetrotrophic** Simuliidae, Tipulidae, Agrionidae, Chlorocyphidae, Calopterygidae	†Emergence Period (Eggs and adult)	No

$^{d}/_{s}$ Hareoli	Riffle	Baetidae, Simuliidae, Tipulidae	No	No	Psychodidae-Chironomidae-Lymneadae:28.5-25-14.2	**No**	No taxa due to habitat loss	**Hetrotrophic** Baetidae, Simuliidae, Tipulidae, Chironomidae
	Pool	Chironomidae, Oligochaeta	No	No	Chironomidae: 94.7	**No**	No taxa due to habitat loss	**Hetrotrophic** Oligochaeta
Agvaanpur	Run; Clay-silt	Gerridae, Corixidae, Nepidae, Notonectidae	Corixidae - Lymnaedae - Gomphidae: 27.9-23.3-20.9 *Gerride	NA	Ceratopogonidae-Chironomidae:48-43	**Autotrophic** Corixidae, Psephenidae, Blepharoceridae All Gastropods	†Emergence Period (Eggs and adult)	**Autotrophic** Corixidae, Psephenidae, Blepharoceridae All Gastropods
	Pool; Clay-silt	NA	NA	NA	Chrinomidae: 90	NA	NA	Autotrophic
Katghar	Run; Clay-silt	Dixidae, Chironomidae,	Chironomidae: (100)	Chironomidae: 100	Naididae: 66 *Glossoscolecidae	**Autotrophic** Corixidae, Psephenidae, Blepharoceridae All Gastropods	Unionidae, Lymnaedae,	**Autotrophic** Corixidae, Psephenidae, Blepharoceridae All Gastropods ,
Chaubari	Run; Clay-silt	Unionidae, Lymnaedae,	Chironomidae: (55.3) * Lestidae >Naucoridae	NA	Chironomidae: 49 *Culicidae	**Autotrophic** Lymnaedae, Corixidae, Psephenidae, Blepharoceridae All Gastropods	†Emergence Period (Eggs and adult)	**Autotrophic** Corixidae, Psephenidae, Blepharoceridae All Gastropods
Dabri	Run; Clay-Silt	Lymnaedae, Unionidae	Chironomidae: 73 *Gerridae	Unionidae: 100	Chironomidae: 64 *Amblemidae	**Autotrophic** Lymnaedae, Corixidae, Psephenidae, Blepharoceridae All Gastropods	†Emergence Period (Eggs and adult)	**Autotrophic** Corixidae, Psephenidae, Blepharoceridae All Gastropods

Note: Taxa/Taxonomic composition (in each season) represented with more than >10% share in present condition have been considered. The taxa with very least abundance (<3%) suggests its rarity and is indicated by an astrix sign (*). † indicates the emergence of the insects from larvae and pupa in the monsoon therefore the adults will be available during monsoon period and individuals may also be present as eggs and pupa; hence represented with more than >10% share in present condition have been considered.

4.2.2 Vertebrate fauna

Mammals (Dolphins and Otters)

Gangetic dolphin

Gangetic dolphins have been declared as the National Aquatic Animal of India and accorded legal protection in the Wildlife (Protection) Act of India, 1972 as Schedule I species. It favors deep pools, eddy counter-currents located downstream of the convergence of rivers and upstream and downstream of mid-channel islands. River pollution, drowning in fishing nets, prey depletion and poaching are major threats. Information on hydraulic habitat requirements of Dolphins for River Ramganga or any other similar river stretch is lacking. However, comparable data from River Ganga is available from a 165km stretch from Narora to Bijnor[17].

Otters

Otters form a well-marked group of species within the mammalian family *Mustelidae*. Adapted for a semi-aquatic life, otters are primarily piscivorous. They are good indicator species of health status of different aquatic ecosystems they inhabit as they are sensitive to degradation along the food chain[18]. Although habitat preference differ from region to region, along River Ramganga in Corbett Tiger Reserve; rocky and sandy stretches with gentle bank slopes, bank side vegetation serving as escape cover, slow water current and prey availability govern the distribution of Otters[19]. The current knowledge on conservation status of Otters in India is limited such that our management decisions are often uncertain towards its benefits, or no decisions at all for want of empirical data.

Reptiles (Crocodilians and Turtles)

Reptiles are important components of the food web filling a critical role both as predator and prey species. They play a vital role in cleaning the freshwater ecosystem feeding on the carcasses of other species. Mugger Crocodile *Crocodylus palustris* is modest sized crocodile with a very broad snout. It is generally found in slow mowing rivers preferring deep pools. Also inhabits swamps and lakes. It feeds on a wide array of vertebrates. They come out of water to bask and often make nests in sand rocks along the riverbanks. Gharial *Gavialis gangeticus* prefer calmer areas of deep, fast-moving rivers. They feed exclusively on fish. Gharial basks and nests on the sandbanks close to the river. The Gharial is the subject of a re-introduction programme in Corbett National Park (CNP), by January 1987, 27 young Gharial had been released in the Park[20]. Presently, healthy populations of Mugger Crocodile and Gharial are reported in River Ramganga and its tributaries flowing across the Corbett Tiger Reserve (CTR)[21]. Five species of freshwater turtles inhabiting River Ramganga and its tributaries in CTR have been reported[22]. During a reconnaissance survey conducted in July (2013) WWF-India Field Team recorded 6 species of turtles[23], listed below:

Spotted pond Turtle *Geoclemys hamiltonii*
Indian black Turtle *Melanochelys trijuga*
Indian flapshell Turtle *Lissemys punctata*
Striped-roof Turtle *Batagur dhongoka*
Indian roofed Turtle *Pangshura tecta*
Brown roofed Turtle *Pangshura smithii*

Although no in-depth information exists on hydraulic habitat requirements of reptilian fauna for River Ramganga, comparable information is available for Gharial from River Chambal[24].

Fish

Of the 2,500 species of freshwater fishes recognized in the Indian subcontinent, 930 are categorized as freshwater species[25]. 124 fish species are listed from the western Himalaya[26] and a total of 218 species are reported from the whole of the Himalaya[27]. Studies of fish population structure in the Ramganaga upstream habitats have been fewer[28]. The fish species distribution in the Himalayan freshwater ecosystems depends on flow rate, nature of substratum, water temperature and the availability of food[29]. River Ramganga has been reported to be the main breeding ground of Golden mahseer *Tor putitora*[30].

Observations recorded during the study period (May 2014 – January 2015)

During the course of the study there were no direct sightings recorded for Dolphins, Crocodilians, and Otters. However, locals at Dabri (Shahjahanpur District) informed sighting dolphins and mugger during floods which disperse from downstream from River Ganga into River Ramganga. Otter occurrence was recorded from Naulla (upstream of Bhikiasain), Marchula and Hareoli wetlands (Figure 18a,b,c). During summer an abandoned den site in natural rock crevices along the river was recorded at Marchula; while an abandoned den site in tree roots was recorded at Naulla during winter. Local fisherman at Hareoli barrage informed that Otters are often seen during monsoon, when the river is in flood and the animals travel long distance chasing their prey (*i.e.* fish). Turtle sightings were best recorded at Dabri during summer and winter surveys. During monsoon one individual each of Brown roofed turtle *Pangshura smithii* and Three striped roof turtle *Batagur dhongoka* were recorded as by-catch during fish sampling at Dabri. Species distribution and habitat requirements (Reference, Observed, and Desired) recorded in the sampling stations along River Ramganga are discussed in Table 6.

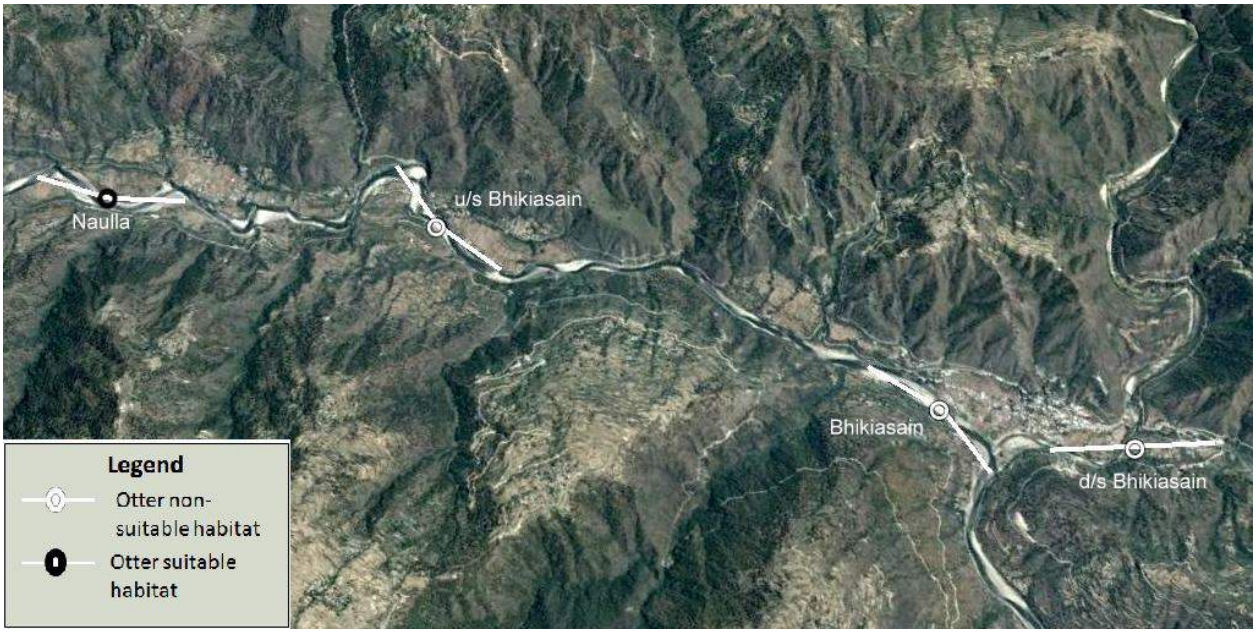

Figure 18a. Suitable Otter occurring site along River Ramganga at Naulla (upstream of Bhikiasain), Uttarakhand.

Figure 18b. Suitable Otter occurring site along River Ramganga at Marchula ($^{d}/_{s}$ Bhikiasain), Uttarakhand.

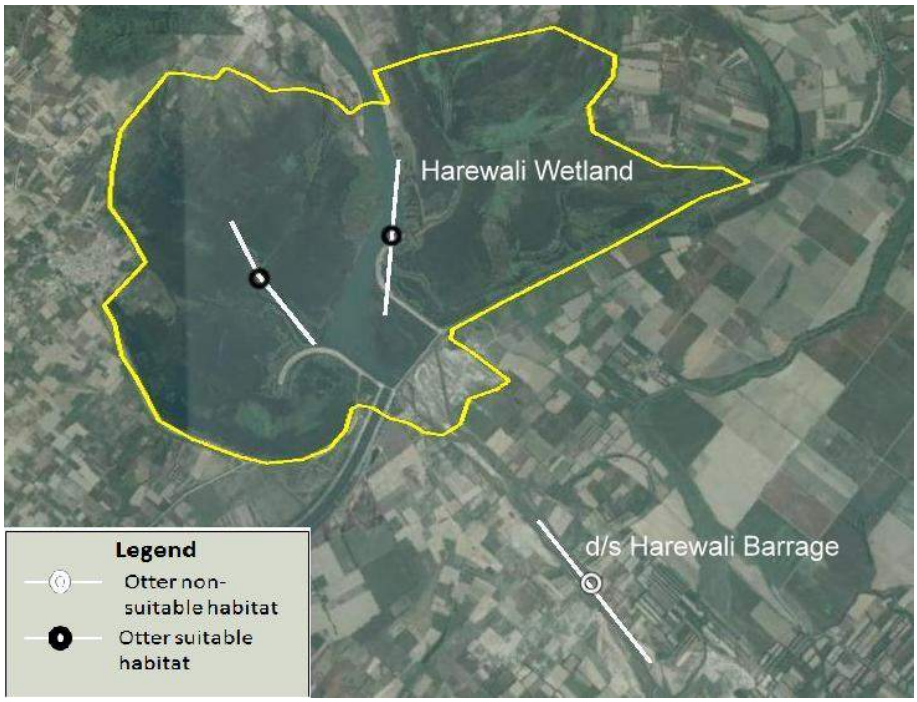

Figure 18b. Suitable Otter occurring site along River Ramganga at Hareoli wetland, Uttar Pradesh.

Table 6. Summary: Species distribution and habitat requirements (Reference, Observed, and Desired) recorded for vertebrate fauna (Mammals and Reptiles) along River Ramganga during the study period (May 2014 – January 2015).

Species	Sampling station	Habitat requirements					Remarks
		Reference	Observed			Desired	
			Summer	Monsoon	Winter		
Crocodilians (Mugger; Gharial) Turtles Otters Dolphin	Bhikiasain	**Crocodilians** Healthy populations are reported from along the protected stretch of the River Ramganga and its tributaries in Corbett Tiger Reserve. No information on hydraulic habitat requirements available for River Ramganga. Comparable study of Bijnor-Narora stretch in River Ganga records – River width: 200m - 1000m; River depth: 0.5m-20.0m; Current velocity: 11.1 m/min **Turtles** 5 species of freshwater turtles are reported inhabiting River Ramganga and its tributaries in CTR. No information on	River width: 10-20m; River depth: 0.50m-1m; Current velocity: Slow-Fast flowing; Prey available; No open sandbanks; No Large sand-rock outcrops; No MCI	River width: 20-50m; River depth: 0.50m->2m; Current velocity: Fast-Very fast flowing; Prey available; No open sandbanks; No Large sand-rock outcrops; No MCI	River width: 20-40m; River depth: 0.50m - 3m; Current velocity: Slow-Fast flowing; Prey available; No open sandbanks; No Large sand-rock outcrops; No MCI	**Mugger** River width: 20-50m; River depth: >3m; Current velocity: Stagnant-Slow flowing; Prey availability; Back waters; Large sand-rock outcrops for basking; Sand-Clay for nesting **Gharial** River width: 20-50m; River depth: >3m; Current velocity: Slow-Fast flowing; Prey availability; Back waters; Mid-channel Islands and Open sand banks for basking; >3m high and 45°	
	Marchula		River width: 10-30m; River depth: 0.50m->3m; Current velocity: Slow-Fast flowing; Prey available; Few open sandbanks and large sand-rock outcrops; No MCI	River width: 15-40m; River depth: 0.75m->3m; Current velocity: Fast-Very fast flowing; Prey available; Few open sandbanks and large	River width: 10-30m; River depth: 0.50m->3m; Current velocity: Slow-Fast flowing; Prey available; Few open sandbanks and large sand-rock outcrops; No MCI		A single mugger was recorded in the upper reaches of Ramganga at Marchula during summer. Good habitat for Otters.

		hydraulic habitat requirements of turtle species available for River Ramganga or any other similar river stretch. Comparable study of Bijnor-Narora stretch in River Ganga records – River width: 200m - 1000m; River depth: 0.5m-20.0m; Current velocity: 11.1 m/min. **Otters** The species is reported from River Ramganga and its tributaries (Mandal, Palain and Kho) in CTR. Ecological studies conducted have highlighted hydraulic habitat requirements. **Dolphins** There are no published records available for the species occurrence in River Ramganga, however anecdotal accounts suggests sightings at a place called Paroor which is about 300km d/s		sand-rock outcrops; No MCI		sloping fine sand banks for nesting **Turtles** River width: 10-50m; River depth: >1m; Current velocity: Slow-moderate flowing; Prey availability; Low lying muddy outcrops and Mid-channel Islands for basking; Sand banks for nesting **Otters** Sandy stretches with gentle bank slopes for grooming; bank side vegetation serving as escape cover; slow-fast flowing water current; prey availability; Natural rock crevices and suitable tree roots to build	
	Afzalgarh		River width: 30-50m; River depth: 0.50m->3m*; Current velocity: Fast-Very fast flowing; Prey available; limited stretches of open sandbanks; No large sand-rock outcrops; No MCI	River width: 35-70m; River depth: 0.50m->3m; Current velocity: Very fast flowing; Prey available; limited stretches of open sandbanks; No large sand-rock outcrops; No MCI	River width: 30-60m; River depth: 0.50m->2m; Current velocity: Very fast flowing; Prey available; limited stretches of open sandbanks; No large sand-rock outcrops; No MCI		Mugger and Otters stray into lower stretch during monsoon (Secondary Information). *Water was released from Upstream. *Since the site is fairly close to the PA it may be used as an travel lane or a feeding ground by Otters
	$^{d}/_{s}$ Hareoli		River width: 10-20m; River depth: 0.50m-1.5m*; Current velocity: Slow-Fast flowing; Prey available; Open sand banks and escape cover in the form of thick and tall riparian (grass) vegetation available; limited MCI available	River width: 10-25m; River depth: 0.50m-2m; Current velocity: Slow-Fast flowing; Prey available; Open sand banks and escape cover in the form of thick and tall riparian	River width: 10-25m; River depth: 0.50m-1.5m; Current velocity: Slow-Fast flowing; Prey available; Open sand banks and escape cover in the form of thick and tall riparian (grass) vegetation available; limited MCI		Mugger and Otters stray into lower stretch during monsoon (Secondary Information). *Water was released from Upstream. *Since the site is fairly close to the PA it may be used as an travel lane or a feeding ground by Otters

		of kalagarh dam. No information on hydraulic habitat requirements of the species available for River Ramganga or any other similar river stretch. Comparable study of Bijnor-Narora stretch in River Ganga records – River width: 200m - 1000m; River depth: 0.5m-20.0m; Current velocity: 11.1 m/min.		(grass) vegetation available; limited MCI available	available	holts (dens) govern the distribution of the species.	
	Agwanpur		River width: 10-30m; River depth: 0.50m->1m; Current velocity: Slow-Fast flowing; Prey available; Limited stretches of open sandbanks; No large sand-rock outcrops; No MCI	River width: 10-50m; River depth: 0.50m->3m; Current velocity: Slow-Very fast flowing; Prey available; limited stretches of open sandbanks; No large sand-rock outcrops; No MCI	River width: 10-40m; River depth: 0.50m->2m; Current velocity: Slow-Fast flowing; Prey available; limited stretches of open sandbanks; No large sand-rock outcrops; No MCI	**Dolphins** The species is exclusively found in freshwater habitat. It occurs in clear, slow-flowing rivers and prefer deep pools, eddy counter-currents located downstream of the convergence of rivers and of sharp meanders, and upstream and downstream of mid-channel islands.	
	Katghar		River width: 10-45m; River depth: 0.50m-1.5m; Current velocity: Slow-Moderate flowing; Prey available; limited stretches of open sandbanks; No large sand-rock outcrops; No MCI	River width: 10-80m; River depth: 0.50m->2m; Current velocity: Fast flowing; Prey available; limited stretches of open sandbanks;	River width: 10-60m; River depth: 0.50m->1.5m; Current velocity: Fast flowing; Prey available; limited stretches of open sandbanks; No large sand-rock outcrops;		

				No large sand-rock outcrops; No MCI	No MCI		
	Chaubari		River width: 15-45m; River depth: 0.50m-1m; Current velocity: Slow-Moderate flowing; Prey available; limited stretches of open sandbanks; No large sand-rock outcrops; No MCI	River width: 20-60m; River depth: 0.50m-1.5m; Current velocity: Fast flowing; Prey available; limited stretches of open sandbanks; No large sand-rock outcrops; No MCI	River width: 20-50m; River depth: 0.50m->1m; Current velocity: Moderate-Fast flowing; Prey available; limited stretches of open sandbanks; No large sand-rock outcrops; No MCI		
	Dabri		River width: 30-50m; River depth: 0.50m-2m; Current velocity: Fast flowing; Prey available; Boulder outcrops along the shore and sand banks for basking and nesting; Deep pools available; Limited stretches of open sandbanks ; No large sand-rock outcrops; MCI available	River width: 30-60m; River depth:1m->5m; Current velocity: Fast flowing; Prey available; Boulder outcrops along the shore and sand banks	River width: 30-50m; River depth: 1m->2m; Current velocity: Fast flowing; Prey available; Boulder outcrops along the shore and sand banks for basking and nesting; Deep pools available; Limited		Dolphin and Mugger disperse up/s from the d/s Ganga-Ramganga confluence during monsoon (Secondary Information). Good habitat for turtles. Two species (Indian Roofed Turtle *Pangshura tecta*; Three-striped Roof Turtle *Batagur dhongoka* recorded.

				for basking and nesting; Deep pools available; Limited stretches of open sandbanks; No large sand-rock outcrops; MCI available	stretches of open sandbanks; No large sand-rock outcrops; MCI available		

Footnote: MCI = Mid channel islands.

Fish

A total of 93 fish species belonging to 62 genera 22 families and 8 orders were recorded. Among these 88 were native species, while 4 were recorded exotic species (*Cyprinus carpio, Cteno pharyngodonidella, Hypophthalmichthys molitrix* and *Hypophthalmichthys nobilis).*

Maximum number (48 species) were recorded at Katgharh followed by (42 species) at Hareoli in the transitional zone between hills and plains and minimum (9 species) at Marchula (winter samples could not be collected because of restrictions on fishing). Overall family Cyprinidae is represented by maximum number of 47 species. As per the IUCN categories; 1 species was recorded Endangered (EN) i.e. *Tor putitora;* 6 species were recorded Near Threatened (NT) i.e. *Tor tor, Labeo pangusia, Wallago attu, Ompok pabda, Hypophthalmichthys molitrix* (exotic species), *Bagarius bagarius.* 2 species are listed as vulnerable (VU) i.e. *Ailiacolia* and *Schizothorax richardsonii.* The rest of the species were either Data Deficient (DD) or Least Concern (LC). Sampling station wise the presence and the absence of the fishes and their habitat preferences are provided in Table 7.

Table 8 presents relative intolerance, frequency of occurrence, reference habitat condition, observed habitat condition and desired habitat condition for *selected* fish species. Although no anomalies or parasitic load were observed from the sampled fishes, however detailed studies are recommended with respect to health rating as per the Fish Assemblage Integrity Index (FAII).

Species relative abundance, characteristics (length and weight), and Catch per Unit Effort (CPUE) are compared among the 8 sampling stations (Table 9). *Garra gotyla gotyla* recorded maximum (31.58%) relative abundance at Marchula; while *Glossogobius giuris* recorded minimum (9.16) relative abundance at Chaubari. CPUE (kg/person/day) was recorded highest (18.53) at Marchula and lowest (5.2) at Afzalgarh. Table 10 presents the occurrence of fish seed of *selected* species recorded at different sampling stations during monsoon (August 2014) along River Ramganga.

Table 7. Fish species recorded in River Ramganga during the study period (May 2014 - January 2015) and reference condition on habitat preference.

S.no	Name of the fish species	Sampling Centres								Common name	Conservation status	Habitat preference (Reference condition)
		B	M	AF	H	A	K	C	D			
	Order-Cypriniformes **Family-Cyprinidae**											
1.	*Cyprinus carpio* (Linnaeus, 1758)				+	+	+	+		Common carp	Exotic	Hardy and tolerant; favours large water bodies with slow flowing or standing water with soft bottom sediments. Thrive in large turbid rivers.
2.	*Crossocheilus latius latius* (Hamilton, 1822)	+	+							Stone roller	Least Concern (LC)	Adults inhabit streams and rivers. Found over gravel and stony bottom of mountain streams.
3.	*Labeo dyocheilus* (McClelland, 1839)	+	+							Boalla/ Kali	Least Concern (LC)	Adults live in clear active currents of large rivers.
4.	*Labeo pangusia* (Hamilton, 1822)								+	Minnorws /Carp	Near Threatened (NT)	Lives in rivers, lakes and ponds (in active currents of large streams and upper reaches of rivers. Feeds mostly on algae and diatoms.
5.	*Labeo calbasu* (Hamilton, 1822)				+	+	+		+	Orange fin Labeo	Least Concern (LC)	Adults occur in rivers in slow-moving waters.
6.	*Labeo gonius* (Hamilton, 1822)					+				Koriya Labeo	Least Concern (LC)	Adults inhabit rivers. They spawn during the southwest monsoon. Do not normally breed in ponds. Artificial breeding done through hypophysation. Cultured in ponds along with other carp species.
7.	*Labeo rohita* (Hamilton, 1822)						+			Rohu	Least Concern (LC)	Adults inhabit rivers. Diurnal and usually solitary. They burrow occasionally. Feed on plants. Spawning season generally coincides with the southwest monsoon. Spawning occurs in flooded rivers.
8.	*Labeo boggut* (Sykes, 1839)						+			Boggut Labeo	Least Concern (LC)	Inhabits upper reaches of rivers. A popular species for stocking ponds.
9.	*Labeo boga* (Hamilton, 1822)							+	+	Boga	Least Concern (LC)	Inhabits large rivers and their tributaries, above tidal influence. Spawns in flooded rivers.
10.	*Devario devario*				+	+	+	+	+	Sind Danio	Least Concern (LC)	Inhabits rivers, canals, ponds, beels and inundated fields. Feeds on worms, small crustaceans and insects.
11.	*Labeobata* (Hamilton, 1822)						+		+	Bata	Least Concern (LC)	Benthopelagic; potamodromous inhabit rivers.
12.	*Labeo angra* (Hamilton, 1822)			+		+			+	Angra Labeo	Least Concern (LC)	Found in rivers, lakes and ponds. Important food and sport fish.
13.	*Bangana dero*(Hamilton, 1822)			+			+			Kalabans	Least Concern (LC)	Adults inhabit torrential hill-streams in shallow waters. They migrate to warmer regions of lakes and streams during winter. Used commonly by anglers as bait for *Raiamas bola* and *Tor putitora*.
14.	*Cirrhinus reba* (Hamilton, 1822)			+			+		+	Reba Carp	Least Concern (LC)	Adults inhabit large streams and rivers. Also found in tanks, canals, ponds, beels and inundated fields.
15.	*Cirrhinus mrigala* (Hamilton, 1822)				+					Mrigal Carp	Least Concern	Freshwater; demersal.

											(LC)	
16.	*Ctenopharyngodonidella* (Valenciennes, 1844)					+	+			Grass Carp	Not Evaluated (NE) and Exotic	Adults occur in lakes, ponds, pools and backwaters of large rivers (preferring large, slow-flowing or standing water bodies with vegetation.
17.	*Hypophthalmichthys molitrix* (Valenciennes, 1844)						+			Silver Carp	Near Threatened (NT) and exotics	Found in their natural range in rivers with marked water-level fluctuations and over-winters in middle and lower stretches, swimming just beneath the surface. They feed in shallow (0.5-1.0 m deep) and warm (over 21°C) waters.
18.	*Tor putitora* (Hamilton, 1822)	+	+	+						Golden Mahseer	Endangered (EN)	Inhabits mountain and sub-montane streams, riverine pools and lakes. Found in rapid streams with rocky bottom and breeds over gravel and stone.
19.	*Tor tor* (Hamilton, 1822)	+								Tor Barb	Near Threatened (NT)	Inhabits rivers and lakes, also in rapid streams with rocky bottom. Grows better in a river with a rocky bottom. Travels towards headwaters at the start of the rainy season and downstream at the end of the rainy season.
20.	*Tor mosal* (Hamilton- Buchanan)	+										Found in Ramganga.
21.	*Garra mullya* (Sykes, 1839)	+	+		+	+	+			Sucker Fish	Least Concern (LC)	Occurs in mountain streams.
22.	*Garra gotyla gotyla*(Gray, 1930)	+	+							Sucker Head	Least Concern (LC)	Adults inhabit streams and lakes. Feed on algae, plants and detritus material.
23.	*Garra lamta* (Hamilton, 1822)	+								Minnows or Carps	Least Concern (LC)	Adults are found in streams and lakes.
24.	*Garra annandalei* (Hora, 1921)	+								Minnows or Carps	Least Concern (LC)	Occurs in mountain streams. Hides under rocks and boulders in swift and clear water streams.
25.	*Esomus danricus* (Hamilton, 1822)				+	+	+		+	Flying Barb	Least Concern (LC)	Inhabits in ponds, weedy ditches and irrigation canals.
26.	*Chela cachius* (Hamilton, 1822)			+	+				+	Silver Hatchet Chela	Least Concern (LC)	Inhabits ponds, ditches and rivers in plains and sub-montane regions.
27.	*Laubuca laubuca* (Hamilton, 1822)			+	+			+		Indian Glass Barb	Least Concern (LC)	Inhabits the middle-depth area of deep area of streams, both in still and relatively fast-flowing waters, depth ranges 0-2m.
28.	*Puntius sophore* (Hamilton, 1822)			+	+	+	+		+	Pool Barb	Least Concern (LC)	Adults inhabit rivers, streams and ponds in plains and sub-montane regions. Found in large rivers with high turbid monsoon flow and with diverse substrate consisting of sand, mud, gravel, pebble, cobble, and boulders.
29.	*Pethia conchonius* (Hamilton, 1822)			+	+		+	+	+	Rosy Barb	Least Concern (LC)	Inhabits lakes and fast flowing hill streams and tolerates low water temperatures.
30.	*Pethia ticto* (Hamilton, 1822)			+		+	+	+	+	Ticto Barb	Least Concern (LC)	Found in still, shallow, marginal waters of tanks and rivers, mostly with muddy bottoms. They browse close to the substrate in shallow waters.
31.	*Osteobrama cotio* (Hamilton, 1822)			+				+	+	Minnows	Least Concern (LC)	Adults occur in rivers, lakes, ponds and ditches. Possibly useful as larvicide.
32.	*Cabdio morar* (Hamilton, 1822)			+	+	+	+	+	+	Morari	Least Concern (LC)	Found in streams and ponds in plains and mountainous regions.
33.	*Barilius gatensis* (Valenciennes, 1844)	+								Minnows or Carps	Least Concern (LC)	Occurs in clear hill streams with gravelly or rocky bottom.
34.	*Barilius vagra* (Hamilton, 1822)	+	+							Dudhnea	Least Concern (LC)	Adults live in hill streams with gravelly and rocky bottom.

35.	*Barilius bendelisis* (Hamilton, 1807)	+	+	+						Khoksa	Least Concern (LC)	Occurs in streams and rivers along the base of hills, with reference to pebbly and rocky bottom.
36.	*Barilius barna* (Hamilton, 1822)	+		+	+					Khoksa/ Dudhnea	Least Concern (LC)	Adults live in hill streams and large rivers. Found in clear hill streams with gravelly bottom.
37.	*Ambly pharyngodonmola* (Hamilton, 1822)			+	+				+	Molacarplet	Least Concern (LC)	Adults are found in ponds, canals, beels, slow-moving streams, nullahs and paddy fields.
38.	*Salmophasiaphulo* (Hamilton, 1822)			+						Fine-scale Razor belly Minnow	Least Concern (LC)	Occurs in the lower reaches of rivers, ponds, beels, ditches and canals.
39.	*Hypophthalmichthys nobilis* (Richardson, 1845)			+	+					Bighead Carp	Data deficient (DD)	Occurs in rivers with marked water-level fluctuations, overwinters in middle and lower stretches. Breeds in very deep, very turbid and warm waters above 18°C (usually 22-30°C), with high current (1.1-1.9 m/s).
40.	*Catla catla* (Hamilton, 1822)					+	+			Catla	Least Concern (LC)	Adults occur in rivers, lakes and culture ponds (Mature individuals breed in rivers (Surface and mid-water feeders).
41.	*Chagunius chagunio* (Hamilton, 1822)			+		+	+			Chaguni	Least Concern (LC)	Adults inhabit large rivers with rocky bottoms, clear and fast water and little or no vegetation.
42.	*Raiamas bola* (Hamilton, 1822)	+		+						Trout Barb	Least Concern (LC)	Adults inhabit rivers and streams; do not have barbells, but with a deep cleft in the mouth.
43.	*Securicula gora* (Hamilton, 1822)			+						Minnows or Carps	Least Concern (LC)	Occurs in rivers, beels and canals. Feeds at the surface on insects, insect larvae and crustaceans.
44.	*Salmophasia bacaila* (Hamilton, 1822)					+	+		+	Large Razor Belly Minnow	Least Concern (LC)	Usually found in slow running streams. Adults occur in rivers, ponds, beels and inundated fields. Are surface feeders on larvae and adults of insects.
45.	*Barilius barila* (Hamilton, 1822)			+		+	+		+	Minnows or Carps	Least Concern (LC)	Adults occur in the large hill stream and shallow clear river along the foot hills.
46.	*Barilius shacra* (Hamilton, 1822)			+	+							Found in large rivers and streams, with diverse substrate consisting of sand, mud, gravel, pebble, cobble, and boulders.
47.	*Schizothorax richardsonii* (Gray, 1832)	+	+							Snow Trout	Vulnerable (VU)	Adults inhabit mountain streams and rivers preferring to live among rocks. Mature individuals breed during April and May.
	Family- Psilorhynchidae											
48.	*Psilorhynchus balitora* (Hamilton, 1822)	+								Balitora Minnows	Least Concern (LC)	Occurs in hill streams and rapids. Inhabits shallow running streams with pebbly and sandy bottom, usually associated with hard substrates.
	Family-Cobitidae											
49.	*Botialohachata* Chaudhuri, 1912	+			+		+		+	Reticulate Loach	Not Evaluated (NE)	Inhabits creeks with rocky and gravel bottom.
50.	*Lepidocephalichthys guntea* (Hamilton, 1822)			+	+	+	+			Guntea Loach	Least Concern (LC)	Found in flowing or even clear standing waters.
51	**Family-Nemacheilidae**											
52.	*Acanthocobitis botia* (Hamilton, 1822)	+	+	+		+		+		Mottled Loach	Least Concern (LC)	Adults inhabit clear water, swift flowing streams with rocky, pebbly and sandy bottoms.
53.	*Paraschistura montana* (McClelland, 1838)				+					Chitai	Not Evaluated (NE)	Adults inhabit small streams with gravelly bottom.

54.	*Aborichthys elongates* Hora, 1921				+		+	+			Least Concern (LC)	Occurs in streams with pebbly bottom.
	Order-Clupeiformes **Family-Clupeidae**											
55.	*Gudusia chapra* (Hamilton, 1822)			+					+	Indian River Shad	Least Concern (LC)	Adults are found in middle and upper reaches of the rivers. Also occurs in ponds, beels, ditches and inundated fields.
	Family-Engraulidae											
56.	*Setipinna phasa* (Hamilton, 1822)							+		Gangetic Hair-fin Anchovy	Least Concern (LC)	A riverine species, but also found in estuaries (presumably tolerates some salinity). Adults feed mainly on mysids and small prawns (reduced feeding during breeding), juveniles feed mainly on copepods. Possibly breeds throughout the year.
	Order-Osteoglossiformes **Family-Notopteridae**											
57.	*Notopterus notopterus* (Pallas, 1769)				+					Bronze Feather-back	Least Concern (LC)	Found in clear streams and enters brackish waters. Adults inhabit standing and sluggish waters of lakes, floodplains, canals and ponds.
	Family-Siluridae											
58.	*Wallago attu* (Bloch & Schneider, 1801)			+	+	+	+	+	+	Padin	Near Threatened (NT)	Found in large rivers, lakes and tanks. A large, voracious and predatory catfish which thrives in heels with grassy margin .Associated with deep, still or slow-flowing water with a mud or silt substrate.
59.	*Ompok pabda* (Hamilton, 1822)				+					Pabdah Catfish	Near Threatened (NT)	Adults inhabit clear as well as muddy rivers, streams, ponds and lakes.
60.	*Sisor rabdophorus* (Hamilton, 1822)					+	+	+	+	Sisor Catfish	Least Concern (LC)	Inhabits streams with sandy bottom and strong currents.
	Family-Bagridae											
61.	*Sperata seenghala* (Sykes, 1839)			+	+	+	+	+	+	Giant River-Catfish	Least Concern (LC)	Found in rivers, canals, beels, ditches, inundated fields and other freshwater areas.
62.	*Sperata aor* (Hamilton, 1822)			+	+	+	+	+		Long-whiskered Catfish	Least Concern (LC)	Found in rivers, ponds, lakes, channels and reservoirs. Predatory, adults feed on small fishes and worms.
63.	*Mystus vittatus* (Bloch, 1794)			+	+	+	+	+	+	Striped dwarf catfish	Least Concern(LC)	Adults inhabit standing and flowing waters. Usually found among marginal vegetation in lakes and swamps with a mud substrate.
64.	*Mystus cavasius* (Hamilton, 1822)					+	+	+		Gangetic Mystus	Least Concern (LC	Found in tidal rivers and lakes; also beels, canals, ditches, ponds, and inundated fields. Its pectoral spine can cause painful wounds. Oviparous, distinct pairing possibly like other members of the same family.
65.	*Mystus tengara* (Hamilton, 1822)				+					Bagrid Catfish	Least Concern (LC	Adults inhabit rivers and ponds in plains and sub-montane regions in flowing and standing waters.
66.	*Mystus bleekeri* (Day, 1877)			+	+	+	+	+	+	Day's Mystus	Least Concern (LC)	Found in lakes, tanks, rivers, canals and beels.

67.	*Rita rita* (Hamilton, 1822)					+				Rita	Least Concern (LC)	Inhabits rivers and estuaries, preferably muddy to clear waters. Generally prefers backwater of quiet eddies. Feeds on insects, mollusks, shrimps and fishes.
	Family : **Erethistidae**											
68.	*Erethistes pusillus* (Müller & Troschel, 1849)				+		+			South Asian River Catfishes	Least Concern (LC)	Occurs mainly in hill streams. Found in muddy parts of the rivers overgrown with vegetation.
	Order-Beloniformes **Family- Belonidae**											
69.	*Xenentodon cancila* (Hamilton, 1822)			+	+	+	+	+	+	Freshwater Garfish	Least Concern (LC)	Inhabits freshwater, primarily rivers.
	Order- Siluriformes **Family- Sisoridae**											
70.	*Glyptothorax telchitta* (Hamilton, 1822)						+	+	+	Sisorid Catfishes	Least Concern (LC)	Lives mainly in hill streams.
71.	*Gogangra viridescens* (Hamilton, 1822)						+			Sisorid Catfishes	Least Concern (LC)	Found in the upper reaches of the rivers.
72.	*Glyptothorax pectinopterus* (McClelland, 1842)					+	+	+		River Cat	Least Concern (LC)	Small, benthic species inhabiting pool and run areas of streams. Found in mountain rapids.
73.	*Gagata cenia* (Hamilton, 1822)						+	+		Gagata	Least Concern (LC)	Found in freshwater and tidal rivers.
74.	*Bagarius bagarius* (Hamilton, 1822)						+	+	+	Goonch	Near Threatened (NT)	Adults inhabit rapid and rocky pools of large and medium-sized rivers. Feed on insects, small fishes, frogs and shrimps. Breed in rivers prior to the beginning of the annual flood season.
	Family- Schilbeidae											
75.	*Ailia colia* (Hamilton, 1822)					+	+	+	+	Gangetic Ailia	Near Threatened (NT)	Adults found in large rivers and connected waters. Inhabits surface to mid waters, and usually occur in shoals.
	Order- Perciformes **Family-Ambassidae**											
76.	*Chanda nama* (Hamilton, 1822)			+	+	+	+	+	+	Elongate Glass-perchlet	Least Concern (LC)	Found in standing and running waters, clear streams, canals, beels, ponds, and inundated paddy fields. Abundant during rainy season.
77.	*Parambassis ranga* (Hamilton, 1822)			+	+	+	+	+	+	Indian Glassy Fish	Least Concern (LC)	Found in sluggish and standing water. A common species proliferating in impoundments. Most abundant during the rainy season.
	Family-Nandidae											

78.	*Nandus nandus* (Hamilton, 1822)			+	+	+				Gangetic Leaf Fish	Least Concern (LC)	Adults occur frequently in ditches and inundated fields. Common in summer months when it is collected from dried-up beds of tanks, beels, and bheries.
	Family-Osphronemidae											
79.	*Trichogaster fasciata* (Bloch & Schneider, 1801)			+	+			+		Banded Gourami	Least Concern (LC)	Occurs in large rivers, estuaries, ditches, ponds and lakes; generally preferring weedy environment.
	Family-Channidae											
80.	*Channa marulius* (Hamilton, 1822)			+	+					Great Snakehead	Least Concern (LC)	Adults occur in sluggish or standing water in canals, lakes, and swamps. Inhabits waters with submerged aquatic vegetation. Usually found only in deep pools in rivers.
81.	*Channa striata* (Bloch, 1793)			+	+					Striped Snakehead	Least Concern (LC)	An adult inhabit ponds, streams and rivers, preferring stagnant and muddy water of plains with reference to swampy areas; but also occurs in the lowland rivers. More common in relatively deep (1-2 m) still water.
82.	*Channa punctata* (Bloch, 1793)			+	+		+	+		Spotted Snakehead	Least Concern (LC)	Found in ponds, swamps, brackish water, ditches and beels. Adults prefer stagnant waters in muddy streams.
	Family-Gobiidae											
83.	*Glossogobius giuris* (Hamilton, 1822)				+	+	+	+	+	Tank Goby	Least Concern (LC)	Found in clear to turbid streams with rock, gravel or sand bottoms.
	Order-Synbranchiformes **Family-Mastacembelidae**											
84.	*Mastacembelus armatus* (Lacepede, 1800)			+	+		+			Zig-zag Eel	Least Concern (LC)	Adults live in highland streams to lowland wetlands with reference to streams and rivers with sand, pebble, or boulder substrate. They seldom leave the bottom except when disturbed. Also occur in still waters. Sometimes stays partially buried in fine substrate.
85.	*Macrognathus pancalus* (Hamilton, 1822)			+	+		+	+		Barred Spiny Eel	Least Concern (LC	Inhabits slow and shallow waters of rivers of plains and estuaries; never recorded above an altitude of 366m. Also found in canals, streams, beels, ponds and inundated fields.
	Family-Claridae											
86.	*Clarias batrachus* (Linnaeus, 1758)				+	+				Philippine Catfish	Least Concern (LC)	Adults inhabit lowland streams (swamps, ponds, ditches, rice paddies, and pools left in low spots after rivers have been in flood). Usually confined to stagnant, muddy water.
	Family-Heteropneustidae											
87.	*Heteropneustes fossilis* (Bloch, 1794)				+		+			Stinging Catfish	Least Concern (LC)	Adults found mainly in ponds, ditches, swamps and marshes, but sometimes occur in muddy rivers.
	Family-Schilbeidae											
88.	*Ailiichthys punctata* (Day, 1872)			+					+	Jamuna Ailia	Data deficient (DD)	Mainly confined to Yamuna-Ganga drainage.
89.	*Eutropiichthys murius* (Hamilton, 1822)					+	+	+	+	Schilbid Catfishes	Least Concern (LC)	Inhabit rivers, streams and canals. Oviparous, eggs are unguarded.
90.	*Eutropiichthys vacha* (Hamilton, 1822)						+		+	Schilbid Catfishes	Least Concern (LC)	Found in rivers, canals and tidal waters. Feed on small fish and insects. Oviparous, eggs are unguarded.

91.	*Neotropius atherinoides* (Bloch, 1794)			+		+				Indian Potasi	Least Concern (LC)	Inhabits freshwater and tidal rivers. Its bright color and small size attract aquarists. Oviparous, eggs are unguarded.
	Order- Mugiliformes Family-Mugilidae											
92.	*Sicamugil cascasia* (Hamilton, 1822)					+		+	+	Yellow-tail Mullet	Least Concern (LC)	Inhabit upper reaches of rivers, Oviparous, eggs are pelagic and non-adhesive
	Total	**18**	**9**	**41**	**42**	**37**	**48**	**33**	**34**			

Note: B: Bhikiasain; M: Marchula; AF: Afzalgarh, H: Hareoli; A: Agwaanpur; K: Kathgarh; C: Chaubari, and D: Dabri.
+ Species occurrence

Table 8. Relative intolerance, Frequency of occurrence, habitat condition (Reference, Observed, and Desired) for *selected* fish species.

S.no	Fish species	(1=Tolerant, 5=Intolerant)	Frequency of occurrence (%) w.r.t. sampling stations	Habitat condition (Reference)	Habitat condition (Observed)	Habitat condition (Desired)
1.	*Crossocheilus latiu slatius* (Hamilton, 1822)	3	25	Adults inhabit streams and rivers. Found over gravel and stony bottom of mountain streams	Found in depth ranging from 0.67-0.99m, water velocity ranging from 0.77-0.98m/s. Inhabiting in Boulders, cobbles, pebbles and coarse sand in channel belt substratum	Current observed condition is desirable for this with gravel and stony bottom of mountain streams
2.	*Labeo dyocheilus* (McClelland, 1839)	4	25	Adults live in clear active currents of large rivers	Found in depth ranging from 0.67-0.99m, water velocity ranging from 0.77-0.98m/s. Inhabiting in Boulders, cobbles, pebbles and coarse sand in channel belt substratum	Water velocity in ideal condition for thriving this species with desirable substratum
3.	*Labeo calbasu* (Hamilton, 1822)	2	50	Adults occur in rivers in slow-moving waters	Found in depth ranging from 0.85-1.62m, water velocity ranging from 0.26-0.48m/s dwelling in fine sand and clay substratum	Depth ranging from 0.85-1.62m, water velocity ranging from 0.26-0.48m/s.
4.	*Labeo rohita*	5	12.5	Adults inhabit rivers. Are diurnal	Observed in river depth up	It's one of the species of Indian

	(Hamilton, 1822)			species and usually solitary. Spawning season generally coincides with the southwest monsoon. Spawning occurs in flooded rivers.	to 0.98 m with water velocity of 0.5m/s dwelling in fine sand and clay substratum	major carp. Depth of the river is important for the survivable of the species. Depth more than 0.98 m with water velocity of 0.5m/s dwelling in fine sand and clay substratum is conducive for this species. With good water quality parameters. Columner feeder.
5.	*Labeo boga* (Hamilton, 1822)	4	25	Inhabits large rivers and their tributaries, above tidal influence Spawns in flooded rivers	Found in depth ranging from 1.62-2.78m, water velocity ranging from 0.36-0.40m/s dwelling in fine sand and clay substratum	Current observed condition is desirable for this fine sand and clay
6.	*Devario devario*	1	62.5	Inhabits rivers, canals, ponds, beels and inundated fields Feeds on worms, small crustaceans and insects	Found in depth ranging from 0.85-2.78m, water velocity ranging from 0.26-0.48m/s. Dwelling in fine sand and clay substratum	Depth ranging from 0.85-2.78m, water velocity ranging from 0.26-0.48m/s. Dwelling in fine sand and clay substratum is favourable for this species.
7.	*Cirrhinus reba* (Hamilton, 1822)	2	37.5	Adults inhabit large streams and rivers. Also found in tanks, canals, ponds, beels and inundated fields	Seen in depth ranging from 0.98-1.5m, water velocity ranging from 0.36-1.25m/s. Dwelling in fine sand & clay and in Boulders, cobbles, pebbles and coarse sand in channel	Inhabit large streams and rivers Current observed condition is desirable for this species.
8.	*Cirrhinus mrigala* (Hamilton, 1822)	5	12.5	Freshwater; demersal. Species of IMC	Seen in of 1.05m with water velocity of 0.26 Dwelling in fine sand & clay substratum	One of the important species of Indian major carp. Bottom feeders. Observed parameters are conducive for this species.
9.	*Tor putitora* (Hamilton, 1822)	2	37.5	Inhabit mountain and submontane streams, riverine pools and lakes. Found in rapid streams with rocky bottom to and breed over gravel and stone	Found in depth ranging from 0.67-1.5m, water velocity ranging from 0.77-1.25m/s dwelling in Boulders, cobbles, pebbles and coarse sand in channel belt	It's a cold water species. Conducive in riverine pools and lakes. Found in rapid streams with rocky bottom to and breed over gravel and stone. Observed habitat is conducive for this species.
10.	*Garra gotyla gotyla* (Gray, 1930)	2	25	Adults inhabit streams and lakes. Feed on algae, plants and detritus	Observed in depth ranging from 0.67-0.99m, water velocity ranging from 0.77-	Conducive in riverine pools and lakes. Found in rapid streams with rocky bottom to and breed over

					0.98 m/s dwelling in Boulders, cobbles, pebbles and coarse sand in channel belt	gravel and stone. Observed habitat is conducive for this species. It's a cold water species
11.	*Barilius vagra* (Hamilton, 1822)	2	25	Adults live in hill streams with gravelly and rocky bottom	Found in depth ranging from 0.67-0.99m, water velocity ranging from 0.77-0.98m/s. Inhabiting in Boulders, cobbles, pebbles and coarse sand in channel belt substratum	observed condition is desirable for this with gravel and stony bottom of mountain streams.
12.	*Catla catla* (Hamilton, 1822)	5	25	Adults occur in rivers, lakes and culture ponds	Seen in river depth Ranging from 0.85- 0.98 m with water velocity of 0.48-0.5m/s dwelling in fine sand and clay substratum	One of the important species of Indian major carp. Surface and mid-water feeders. Observed parameters are conducive for this species.
13.	*Schizothorax richardsonii* (Gray, 1832)	2	25	Adults inhabit mountain streams and rivers preferring to live among rocks. Mature individuals breed during April and May.	Observed in depth ranging from 0.67-0.99m, water velocity ranging from 0.77-0.98 m/s dwelling in Boulders, cobbles, pebbles and coarse sand in channel belt	One of the old water species preferring to live among rocks. Observed parameters are conducive for this species
14.	*Sisor rabdophorus* (Hamilton, 1822)	4	50	Inhabits streams with sandy bottom and strong currents	Seen in depth ranging from 0.85-2.78m, water velocity ranging from 0.36-0.48m/s. Inhabiting in fine sand and clay substratum	Current observed condition is desirable for this with fine sand and clay substratum
15.	*Sperata seenghala* (Sykes, 1839)	2	75	Found in rivers, canals, beels, ditches, inundated fields and other freshwater areas.	Seen in depth ranging from 0.85-2.78m, water velocity ranging from 0.36-1.25m/s. Inhabiting in fine sand and clay, boulders, cobbles, pebbles substratum	Current observed condition is desirable for this with in fine sand and clay, boulders, cobbles, pebbles substratum. Sometimes found in inundated fields and other freshwater areas.
16.	*Mystus bleekeri* (Day, 1877)	2	75	Found in lakes, tanks, rivers, canals and beels	Observed in depth ranging from 0.85-2.78m, water velocity ranging from 0.26-1.25m/s. Inhabiting in fine sand and clay and boulders, cobbles, pebbles substratum	Current observed condition is desirable for this with fine sand and clay substratum and sometimes occurs river canals and wetlands.

17.	*Xenentodon cancila* (Hamilton, 1822)	2	75	Inhabits freshwater, primarily rivers.	Observed in depth ranging from 0.85-1.62m, water velocity ranging from 0.26-1.25m/s. Inhabiting in fine sand and clay and boulders, cobbles, pebbles substratum	Present observation is suited for this species in rivers.
18.	*Channa marulius* (Hamilton, 1822)	2	25	Adults occur in sluggish or standing water in canals, lakes, and swamps. Inhabit waters with submerged aquatic vegetation. Usually found only in deep pools in rivers	Observed in depth ranging from 1.05-1.5m, water velocity ranging from 0.26-1.25m/s. Inhabiting in fine sand and clay and boulders, cobbles, pebbles substratum	Sluggish or standing water in canals, lakes, and swamps. Inhabit waters with submerged aquatic vegetation
19.	*Glossogobius giuris* (Hamilton, 1822)	3	62.5	Found in clear to turbid streams with rock, gravel or sand bottoms	Observed in depth ranging from 0.85-2.78m, water velocity ranging from 0.26-1.25m/s. Inhabiting in fine sand and clay and boulders, cobbles, pebbles substratum	Current observed condition is desirable for this with clear to turbid streams with rock, gravel or sand bottoms
20.	*Clarias batrachus* (Linnaeus, 1758)	3	25	Adults inhabit lowland streams (swamps, ponds, ditches, rice paddies, and pools left in low spots after rivers have been in flood Usually confined to stagnant, muddy water	Seen in depth ranging from 0.85-1.05m, water velocity ranging from 0.26-0.48m/s. Inhabiting in fine sand and clay substratum	Highly costly fish for it's its flesh Current observed condition is desirable for this with fine sand and clay substratum and sometimes occur in muddy rivers. Usually confined to stagnant, muddy water.
21.	*Heteropneustes fossilis* (Bloch, 1794)	3	25	Adults found mainly in ponds, ditches, swamps and marshes, but sometimes occur in muddy rivers.	Observed in depth ranging from 0.98-1.05m, water velocity ranging from 0.26-0.4m/s. Inhabiting in fine sand and clay substratum	Air breathing catfish. Highly costly fish for its flesh Current observed condition is desirable for this with fine sand and clay substratum and sometimes occur in muddy rivers.

Table 9. Relative abundance, morpho-metric characteristics, and CPUE of selected species recorded during the study period (May 2014-January 2015).

Parameters	Bhikiasain	Marchula	Afzalgarh,	Hareoli	Agwaanpur	Kathgarh	Chaubari	Dabri
Max. Length (mm)	*Labeo dyocheilus* (362)	*Labeo dyocheilus* (400)	*Channa marulius* (370)	*Channa marulius* (370)	*Mystus aor* (180)	*Channa punctatus* (230)	*Channa punctatus* (220)	*Xenentodon cancila* (210)
Min. Length (mm)	*Paraschistura montana* (100)	*Paraschistura montana* (100)	*Nandus nandus* (75)	*Erethistes pussilus* (40)	*Puntius ticto*(50)	*Glyptothorax telchitta* (40)	*Puntius conchonius* (50)	*Puntius ticto* (50)
Max. weight (g)	*Labeo dyocheilus* (630.6)	*Labeo dyocheilus* (626)	*Sperata seenghla* (389)	*Channa marulius* (332)	*Catla catla* (78.2)	*Cirrhinus reba* (105.9)	*Channa punctatus* (135.2)	*Mystus bleekeri* (62.1)
Min. weight (g)	*Barilius vagra* (9.1)	*Tor putitora* (15.8)	*Macrognathus pancalus* (5.1)	*Chanda nama* (5.2)	*Puntius ticto* (2.4)	*Macrognathus pancalus* (1.8)	*Puntius conchonius* (2.5)	*Puntius ticto* (2.1)
Highest relative abundance (%)	*Barilius bendelisis* (24.53)	*Garra gotyla gotyla* (31.58)	*Chanda nama* (23.36)	*Puntius sophore* (13.08)	*Mystus bleekeri* (15.66)	*Clupisoma garua* (9.88)	*Glossogobius giuris* (9.16)	*Cabdiomorar* (14.26)
CPUE (kg/person/day)	9.088 during pre-monsoon	18.53 during pre-monsoon	5.2 during monsoon	10.05 during monsoon	9.216 during monsoon	8.1 during monsoon	4.76 during monsoon	6.208 during monsoon

Table 10. Fish seed of *selected* species recorded at different sampling stations during monsoon (August 2014) along River Ramganga.

S. no	Fish species	Bhikiasain	Marchula	Hareoli	Agwanpur	Katghar	Chaubari	Dabri	Afzalgarh
1.	*Catla catla*				+	+	+	+	+
2.	*Cirrhinus mrigala*			+	+	+	+	+	+
3.	*Cirrhinus reba*			+	+	+	+	+	+
4.	*Clarius batrachus*				+				
5.	*Labeo bata*				+	+			+
6.	*Labeo calbasu*				+			+	
7.	*Labeo rohita*			+	+	+	+	+	+
8.	*Mastacembelus armatus*			+		+			+
9.	*Mystus aor*			+	+	+	+	+	+

SYNTHESIS

River Ramganga drainage system is having greater conservation implication since distribution and abundance of several wildlife species are known to revolve around these water source. Although no in-depth information exists on hydraulic habitat requirements of fauna for River Ramganga (West), the present study confirms the distribution of fauna hitherto unreported. The river forms a refuge to a number of endemic, depleted and threatened aquatic species.

The study provides a foundation for establishing e-flows, however a larger sample size/data sets could further improve the diagnostic power and scientific basis for setting ecologically protective minimum flow targets particularly in case of higher vertebrates such as Otters, Dolphins, Crocodilians, and Turtles.

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