Bulletin of Pure and Applied Sciences
Vol.40A (Zoology), No.1,
January-June 2021: P.28-38

Print version ISSN 0970 0765
Online version ISSN 2320 3188
DOI 10.5958/2320-3188.2021.00005.X

Content Available online at: https://www.bpasjournals.com/zoology

Original Research Article

Analysis of Heavy metals and Physico-chemical Parameters of Water in Feeding Habitats of *Ardeola grayii*

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Article Info:
Received on 22.09.2020
Accepted on 01.01.2021
Published on 15.06.2021

ABSTRACT:
The aim of this study was to determine the levels of some physico-chemical parameters of water from feeding sites of *Ardeola grayii*. Water samples were collected from five feeding sites of *Ardeola grayii* as site 1 to 5 for the determination of BOD, COD, DO pH, Chloride, Alkalinity, Total hardness as calcium carbonate, and magnesium carbonate. Samples were also collected for determination heavy metals such as; Cd, Cr, Pb, Hg, Mn, and Zn. Statistical analysis was done by SPSS and Graph pad prism 5. The concentration of DO, BOD, COD was higher in site 2 and site 4. As a result that contaminated water was lethal for aquatic organism and directly or indirectly it affects *Ardeola grayii*. The concentration of Cd, Pb, and Hg was higher in site 2, 3 and 4 than CPCB limits indicating severe contamination in these sites. Due to presence of these anthropogenic substances, *Ardeola grayii* shifted their feeding habitats and behaviour, which is not good for ecosystem. On the contrary, if such pollutants continue to occur for a longer then it may leads to the extinction of rest of the species. Monitoring should be continuously done in order to alleviate pollutants and maintain proper food chain of these aquatic ecosystems.

Keywords: Physico-chemical properties, Heavy metals, Behaviour, Pollutants

INTRODUCTION

Wetlands are the major players in maintaining water cycle and habitats for all wading birds. It provides breeding sites and resting ground for many birds and also inhibits aquatic insects and fishes. Aquatic insects that are major component of wetland ecosystem, providing good sources of food for, fishes and for *Ardeola grayii*, thus a making a complete food chain in an ecosystem. Wetlands are also used by human long ago as aquaculture for rearing prawn, fishes. There has been a strong relationship between human activity and disturbance of the aquatic environment (Hodkinson et al. 2005).

Wading birds and aquatic organisms are dependent for their daily activities on water bodies, and it has the ability to detect, discriminate, and respond to the pollutants and are also sensitive to both beneficial and harmful chemicals. Recent findings have proposed that deterioration of water quality is because of excess acidification and the presence of nitrogen,

How to cite this article: Dwivedi, A., Elangovan, V., Verma, M. (2021). Analysis of Heavy metals and Physico-chemical Parameters of Water in Feeding Habitats of *Ardeola grayii*. *Bulletin of Pure and Applied Sciences-Zoology,* 40A(1), 28-38.

phosphorus, heavy metals, organic toxicants, and pesticides (Bloxham et al. 1999). Pollutants introduced to the environment have impact on ecosystems, and is found in the whole biosphere.

Physico-chemical contamination may affect ecosystems, causing changes in the functions of particular organisms (Bhat et al. 2009). Lucknow the capital of Uttar Pradesh situated on the bank of the river Gomati, which is the habitat of faunal diversity. Unfortunately due to intense colonization, discharge of harmful industrial wastes, cutting of trees, conversion of agriculture field into buildings, its air and water quality are not healthy and sometime air quality index reached to 493 (CPCB), water reservoirs has severely impacted (Canpolat and Calta, 2001).

Ardeola grayii can be easily seen in both urban and rural area but due to decreasing waterbody in urban area of Lucknow, its population is decreasing rapidly.

In the present study*, Ardeola grayii* is used as indicator for habitat quality. Birds are considered good bio- indicators on habitat quality and the effectiveness of ecosystem, providing services to ecosystem and humans, as well as a good indicator of pollution and biodiversity. They are one of the connecting links of the food chain in the ecosystem and having important role in their habitats. There is reciprocal relationship between environment and birds. Environment provide essential factors such as resting, breeding, feeding, ground for their survival while birds contribute direct and indirect role in maintaining environment or modifying certain environment components (Ried, 1991 ; Block and Brennan 1993). In addition, birds are considered as an excellent communication means to raise awareness of biodiversity issues in a way that many organisms cannot (Gregory and Strien, 2010).

Water pollution is becoming a big problem for biodiversity. The main source of water pollution are industrial waste, domestic waste, sewage wastage which directly flow in water body and acid rain is also contribute in water pollution which cause deposition of heavy metals in waterbodies Obasohan et al., 2008.

Fresh water is a source for the development of civilizations but due to pollution there is severe threat to natural fresh water reservoir (Benjamin et al., 1996). The impairment of water quality due to introduction of pollutants is a problem faced by most industrial cities around the world. Rapid urbanization and industrialization with improper environmental planning often lead to discharge of industrial and sewage effluents into wetlands. The wetlands have a complex and fragile ecosystem, as they do not have a self-cleaning ability and therefore readily accumulate pollutants.

Heavy metals entering the water body would be adsorbed in sediments, and subsequently might migrate as a result of exchanges between water, sediment, and biota, through biological and chemical process. Heavy metals do not degrade in water but are generally not found in high concentrations, primarily due to deposition in sediments but also because of uptake by aquatic organisms. Birds are exposed to heavy metals through air, water and their food. Once a metal has entered the body it can be stored or accumulated, or be excreted (Dauwe et al. 2000).

Heavy metals impact on metabolic and reproductive ecology of birds. Water quality influences the availability and accessibility of prey items to various aquatic predators. The water quality is important in waterbird habitat assessment because a host of interacting physical and chemical factors can influence the level of primary productivity in aquatic systems and thus influence the trophic structure and total biomass throughout the aquatic food web (Wetzel 1975).

The physico-chemical characteristics of the water largely determine the waterbird community of wetland habitats, primarily by their direct and indirect impact on the availability and abundance of the birds' prey (Nagarajan & Thiyagesan 1996).

The physico-chemical environment can also directly and indirectly affect waterbirds daily activities. In a direct way, for example, different species of shorebird are constrained morphologically to forage at specific water depths (Safran et al. 1997).

Indirectly, however, physiochemical variables such as salinity and acidity affect the distribution and richness of benthic invertebrates (Courtney and Clements 1998, Leland and Fend 1998, McRae et al. 1998), which in turn can affect the feeding ecology of waterbirds.

So due to all these pollutants either wastage dumped in water or metals present in trophic levels causes variations in the water bodies which disturb the biodiversity (Odum et al., 1971). These variations such as pH, BOD, COD, DO, Chloride, hardness, calcium carbonate, magnesium carbonate, alkalinity in the freshwater bodies. The aim of the present study was to discuss physico-chemical parameters and heavy metals present in water, sample collected from feeding ground of *A.grayii.* This study were divided into three parts, in first and second part physico-chemical parameters and heavy metals of water analysed, and in last contaminated area and less contaminated feeding habitats of *A.grayii* was observed to see there was any different or unique behaviour showed by it. Behaviours were observed during feeding and resting time of *A.grayii.*

MATERIALS AND METHODS

In order to analyse physico-chemical and heavy metals in wetlands, water samples were collected in twice a month in replicates in urban and rural area of lucknow from September 2016 to February 2019, in pre-cleaned polyethylene bottles. The surface water samples were thoroughly filtered through cellulose nitrate filter paper to eliminate suspended solids and stored in plastic bottles with one liter capacity. For the measurement of dissolved oxygen (DO) and biological oxygen demand (BOD), separate 300 ml clean glass stopper BOD bottles were used for sample collection (standard volumetric Winkler's method). For metal analysis, 5 ml nitric acid was immediately added after collecting the samples, for heavy metal samples were collected separately. Digested samples were placed in pre-washed polyethylene bottle, various standards of heavy metals were prepared from certified standard stock solution (ppm) by using double distilled water. These standards were used to obtain calibration curve on Atomic Absorption Spectrophotometer. Effect of pollutants and changes in physico-chemical parameters of water on *A.grayii* behaviour was also observed. Water samples were analyzed for heavy metals (Pb, Cd, Cr, Hg, Zn and Mn) in Atomic Absorption Spectrophotometer. All parameters and procedures followed from CPCB 2008, and APHA 2005. Normality of data were analysed through SPSS (version 21.0) for every year data, mean ±SD values were taken, and graph created by Graph pad prism 5.

RESULTS

In this study it was observed that the polluted wetlands were generally occupied by *A.grayii* cattle egrets, and moorhen other wading birds were little in number, But due to very few availability of prey in polluted wetland, *A. grayii* had to wait for longer and observed to frequent changes of feeding positions and foraging patches.

Physico-chemical parameters:

The physico-chemical environment of water functions in many ways and employs the influences upon biotic components, thus, giving a picture of the environmental suitability of water to maintain life (Kumar and Singh, 2002). Temperature affects various chemical and biological reactions taking place in water and aquatic organisms (Shrivastava and Patil, 2002) and depends upon the season, time of sampling and also upon the temperature of effluent which is being added into the river. The values of different physico-chemical parameters of the water of different area of lucknow (upto 50 km) from all the samplings points during Sep 2016 to Feb 2019 are given in Table 1, 2, and 3. The values are the mean ± SD values of observation from all the 5 sampling points. In this study it was observed that how water quality affects *Ardeola grayii* foraging activity, and mostly affected thing was diversity of aquatic birds which depend on waterbodies for feeding. The mean variations (Mean±SD) of the water physico-chemical parameters for the 3-year study periods are given in the Tables 1, 2 and 3, respectively. In this study 3 year observation was done, in 2016-2017 in all five habitats pH was ranges between 6.3 – 6.9, too much fluctuation in pH are stressful and can even be lethal to aquatic organisms, which may circulate in a food chain. Levels of pH too high (> 9) or too low (< 5) can kill aquatic life (Younos 2007).

Table1: Variation in Physico-chemical parameters of water in different feeding habitats of *Ardeola grayii* from 2016-2017 (all values are given in Mean±SD)

Physico-chemical parameters	S1	S2	S3	S4	S5
pH	6.3±0.15	6.5±0.3	6.4±0.1	6.9±0.15	6.6±0.37
BOD	23.76±1.49	29.03±1.00	14.4±0.60	5.06±0.51	24.73±1.45
COD	23.19±0.45	27.82±0.20	18.38±0.47	14.69±0.37	26.88±0.32
Chloride	50.1±0.1	59.8±0.62	22.10±0.20	36.2±0.15	31.93±0.20
Dissolved oxygen	6.3±0.20	4.3±0.20	6±0.1	7.1±0.2	7.36±0.15
Total hardness calcium as calcium carbonate (mg/l)	165.1±0.1	311.36±1.18	294.6±4.16	144.2±1.08	137.7±8.63
Calcium as calcium carbonate	29.6±0.45	46.1±0.1	33±0.78	55.4±0.4	50.63±0.37
Magnesium as magnesium carbonate	22.1±0.2	47.3±0.20	47.21±0.26	60.7±0.61	32.13±0.90
Alkalinity	103.03±1.76	361.7±0.60	255.3±1.18	111.46±1.28	323.2±0.26

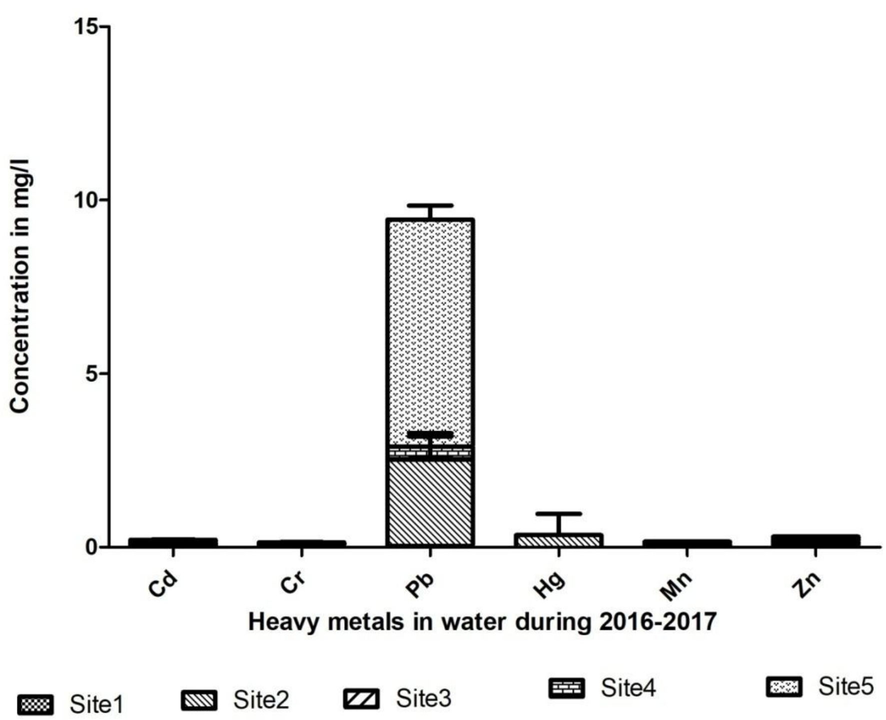

Figure 1: Heavy metals present in water for all five feeding sites of *Ardeola grayii* in 2016-2017

Table 2: Variation in Physico-chemical parameters of water in different feeding habitats of *Ardeola grayii* 2017-2018 (all values in Mean ±SD)

Physico-chemical parameters	S1	S2	S3	S4	S5
pH	6.3±0.32	7.8±0.25	7.23±0.15	7±0.1	6.9±0.41
BOD	27.43±1.06	8.9±0.6	16±0.1	35.1± 0.1	27.7±0.55
COD	29.7±0.5	41.8±0.5	32.8±0.37	34.43±0.30	32.3±1.10
Chloride	43.3±1.07	54.16±1.5	20.83±0.6	42.2±0.9	40.7±0.25
Dissolved oxygen	5.5±1	4.6±0.50	5.03±0.15	6.1±0.35	5.46±0.35
Total hardness calcium as calcium carbonate (mg/l)	167.9±0.05	308.7±2.3	299.8±0.72	167.83±0.40	308.7±2.3
Calcium as calcium carbonate	28.3±0.46	44.83±0.5	33.1±0.3	32±0.69	60.9±0.7
Magnesium as magnesium carbonate	21.34±0.9	47.16±1.35	47.3±0.26	44.7±0.55	56.5±0.39
Alkalinity	106.7±2.3	357.5±6.5	298.4 ± 2.4	166.43±1.64	319.8±0.66

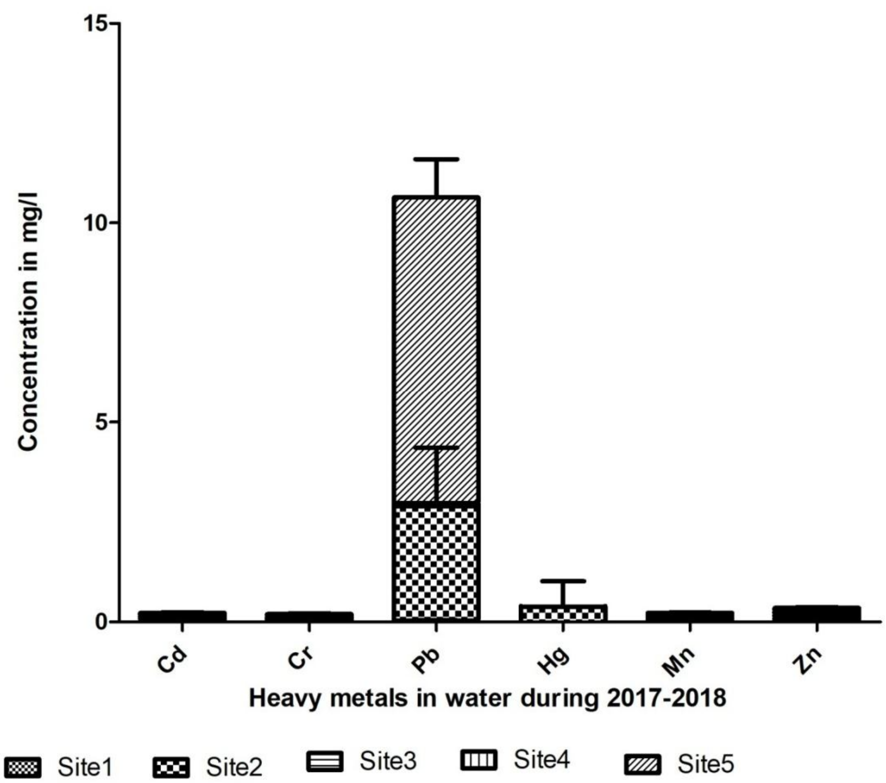

Figure 2: Heavy metals present in water for all five feeding sites of *Ardeola grayii* in 2017-2018

Table 3: Variation in Physico-chemical parameters of water in different feeding habitats of *Ardeola grayii* 2018-2019 (all values are given in Mean±SD)

Physico-chemical parameters	S1	S2	S3	S4	S5
pH	7.06±0.15	8.1±0.26	7.03±0.15	7.5±0.36	8.03±0.15
BOD(mg/l) 3 days at 27°C	27.3±1.70	12.5± 0.20	17.2±0.9	43.2±2.74	41.3±1.21
COD(mg/l)	24.7±0.50	60.7±2.08	33.3±0.9	31.4±4.3	34.3±1.1
Chloride (mg/l)	44.7 ±0.5	62.1±1.90	22.7±0.5	28.6±0.7	45.3±0.25
Dissolved oxygen	7.3±0.20	3.8±0.25	6.2±0.15	5.3±0.47	4.56±0.32
Total hardness as calcium carbonate	155.3±1.01	333.9±11.1	266.8±11.5	176.1±0.86	351.06±5.5
Calcium as calcium carbonate	26.4±1.15	45.16±4.3	36.9±0.68	41.6±1.37	61.46±1.5
Magnesium as Magnesium carbonate	25.27±1.00	50.5±1.70	40.2±1.11	57.9±0.62	51.5±0.6
Alkalinity	113.7±5.8	322.13±4.3	295.7±4.2	181.9±0.78	311.5±1.22

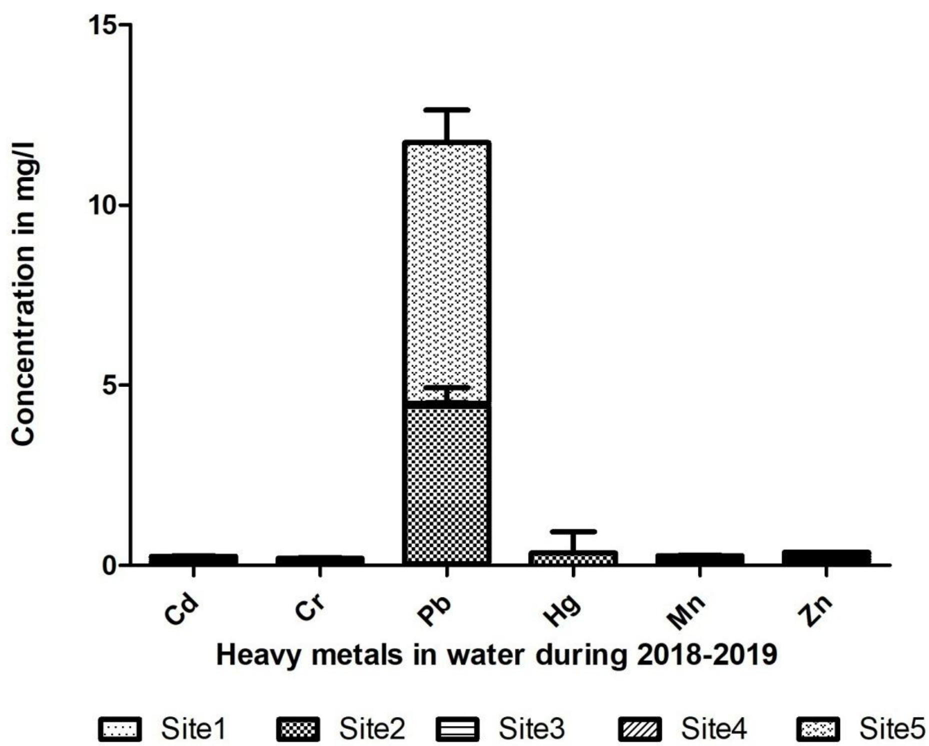

Figure 3: Heavy metals present in water for all five feeding sites of *Ardeola grayii* in 2018-2019

Biochemical Oxygen demand determines the amount of oxygen required for biological oxidation of organic matter with the help of microbial activities. In the present study the value of biochemical oxygen demand ranged between 5.06 to 29.03 mg/L (Table1).

Chemical oxygen demand determines the amount of oxygen required for chemical oxidation of most organic matter and oxidizable inorganic substances with the help of strong chemical oxidant. High COD indicates the presence of all forms of organic matter, both biodegradable and non-biodegradable, and hence the degree of pollution in waters. In the present study the value of COD ranged between 14.69 to 27.82 mg/L which show its high pollution status in S-2 and S-5 sites due to input of domestic drains, dumped plastics, hospitalized wastages, the use of soap and detergents in bathing and washing purposes.

Dissolved oxygen for all five habitats was 4.3 – 7.36 mg/l, DO > 5 mg/l is considered favourable for growth and activity of most aquatic organisms; DO < 3 mg/l is stressful to most aquatic organisms, while DO < 2 mg/l does not support fish life (USEPA 1999). In this study site 2 was having oxygen deficit than others four, site 2 was a very large lake but due to increasing population it was day by day shrinking and filled with garbage. Alkalinity in this study was ranges from 103.03 – 361.7 mg/l. the lake can be categorized as nutrient rich water body and highly productive on the basis of total alkalinity. If any water body have > 20mg/l alkalinity is good for community production, it is also the measure of buffering capacity of water. It is important to assess the alkalinity of water bodies to determine the ability of neutralizing the acidic pollution of water from rainfall of waste water. Total alkalinity is measured on the basis of some components such as bicarbonate, carbonate and hydroxide.

According to Durrani (1993) withdrawal of CO_2 from the bicarbonates for photosynthesis by algae may increase total alkalinity. In this study S-2 and S-3 was having high alkalinity, S-3 was near to temple so by religious activities, people feed fish that causes pond become nutrients rich.

Chloride is found widely distributed in nature in the form of salts of sodium, potassium and calcium. The chloride status in water is indicative of pollution, especially of animal origin. In the present study chloride concentration was found ranging between 22.10 to 59.8 mg/L (table1). Site -2 was having more chloride level due to large amount of organic matter, waste of animals dumped in lake.

Total hardness of water is the measure of alkaline earth elements such as calcium and magnesium in an aquatic body along with other ions such as aluminium, iron, manganese, strontium, zinc, and hydrogen ions. In this study the total hardness of water range was 137.7 to 311.36mg/l in study area. Site 2 had highest 311.36mg/l total hardness in water.

As the content of Ca and Mg in water increases, the content of hardness also shoots up. The average value of calcium hardness for the study period was 29.6-55.4mg/l, whereas the average value for Mg^{2+} recorded was 22.1-60.7 mg/l for the study period. Calcium and magnesium are the dominant cations in an aquatic body. Higher concentration of calcium and magnesium is due to the dissolution of carbonate minerals in water through rainwater mixing, while a lower concentration is due to increased photosynthetic activity of aquatic organisms (Divya 2013).

In 2017-2018 (Table 2) it was observed that, site 2 (7.8 pH) and site 3 (7.23 pH) become slightly alkaline than other three sites. In site 2, DO (4.6mg/l), BOD (8.9 mg/l) lowest and highest COD (41.8mg/l) was observed. Total hardness was maximum in site 2 (308.7mg/l) and site 5 (308.7mg/l), calcium and magnesium was maximum in site 5(56.5 – 60.9mg/l). Alkalinity was observed maximum in site 2 (357.5 mg/l) and site5 (319.8 mg/l).

In 2018-2019, it was observed that (Table 3), site 2 (8.1 pH) and site 5 (8.03pH) was alkaline than other three sites, BOD was minimum in site2 (12.5mg/l), COD maximum in site2 (60.7mg/l), and dissolved oxygen minimum in site 2 (3.8 mg/l) and in site 5 (4.56mg/l). Total hardness of water was maximum in site 2 (333.9 mg/l) and site 5 (351.06 mg/l).

Due to urbanization and industrial processes large quantities of pollutants have continuously been entered into ecosystems. Metals are persistent pollutants that can be biomagnified in the food chains, becoming increasingly dangerous to human and wildlife. This has led to the development of monitoring schemes aimed at directly measuring levels of contaminants in various organisms, and biomonitoring schemes that use indicator species to estimate the levels in other parts of the ecosystem.

Birds, like other organisms, are harmed by heavy metals. For example, metals were affect birds immune system, increase aggressive behaviour, territorial song, and reproductive dysfunction, increased susceptibility to disease and stress and changes in behavioural pattern.

Heavy metals are frequent waste products of industrial and agriculture processes, they enter the food chain via air, water, soil, and biota and their accumulation increases at higher levels of food chain (Burger, 1993). Heavy metals can have harmful effects on development, behaviour and intelligence both in animals and humans (Finkelstein et al., 1998). In this study Cd, Cr, Pb, Hg, Mn and Zn were tested for all five feeding sites of *Ardeola grayii*, it was observed that, in all feeding sites Cr, Mn, and Zn was present in equal proportion than Pb, Cd, and Hg , first three Cr, Mn, and Zn not too much harmful than Pb, Cd, and Hg. In this study for all four year (2019-2019) data were compared by using graph by using mean, SD values and Heavy metals present in water for all five sites of *Ardeola grayii* are given in Figure 1, 2 and 3.

During 2016-2017 lead was present in site 5, site2 followed by site4, mercury present only in site 2.

During 2017-2018, Lead was maximally present in site 5 followed by site2, and mercury present in site 2.

During 2018-2019, level of heavy metals present in all five feeding sites of *Ardeola grayii* was differed for site 2 and site 5, Pb was maximally present in site 5 followed by site2 (Fig. 3), in site Hg also present it indicates site 2 was more contaminated than other four sites.

Table 4: Different pollutants present in feeding habitats and their impact on behaviour of *Ardeola grayii*

Feeding sites	Pollutants	Change in behaviour
Site-1	Domestic waste disposal site,	Flee behaviour, changes in flight distance
Site-2	Misuse of pond as sewage and domestic waste disposal site , water hyacinth	Flee behaviour, aggression, changes in foraging behaviour
Site-3	Being in proximity to religious complex, people use plastic bags, matchsticks, incense sticks, milk packets, disposable utensils, earthen pots, etc. that are often carried to pond by winds.	Flee behaviour, increase in tolerance level
Site-4	Dumped garbage in pond	Not much contaminated as other sites, normal behaviour seen
Site-5	Tannary waste, automobile wastages	Flee behaviour,

Behaviour is suggested to be a more useful indicator or biomarker than standard assays in laboratory conditions because the harmful effects of pollutants sometimes become only noticeable in natural ecological conditions, such as social stress or infections (Zala and Penn 2004).

In this study it was observed that, *Ardeola grayii* behaviour differed in urban and rural area, because urban areas more polluted than rural area. Site 2 and site 5 was polluted compare to other three sites.

Site 1 was large in size and it inhabitants many water birds, it was not much contaminated, but human disturbance occur there, as a result *Ardeola grayii* seen to frequent change foraging patches.
Anthropogenic activities are some of the major factors in the study area posing significant threat to these wetlands. Water hyacinth has rapidly covered the water surface in Site 2 Lake, thereby, reducing the foraging area for open-water birds. These large, unwanted monotypic stands of water hyacinth could reduce the value of the wetland as potential *Ardeola grayii* habitat (Manral et al. 2013).

Site 3 was polluted due to dumping of wastes materials (such as plastics, polythene bags, chips packets), bathing and offering made in the ponds, during mass bathing by local people are influencing the water quality and avifauna.

Site 4 was in rural area less polluted only fleeing behaviour observed there. Site 5 was also in rural area but it was near to tannery factory so water contaminated.

Ardeola grayii is highly susceptible to continuous anthropogenic pressures in the form of washing clothes, cattle bathing, cattle grazing, and entry of domestic sewage, hunting, fishing, and expansion of crops lands.

Pollution of the environment is one of the terrible ecological disaster to which they are subjected nowadays. Nearly all of the activities of human society have produced unfavourable effects on all living forms in the biosphere. The cause of water pollutants are domestic sewage, detergents, pesticides, chemicals, dead materials and industrial effluents through a variety of processes. Sustaining healthy ecosystems that can save from harm to the organisms existing within them, including humans, necessitates not only ecological planning and management, but also knowledge of how stressors vary in the atmosphere (Burger et al. 2004). More and more it is essential to appreciate the outcome and effect of pollutants to evaluate the health of ecosystems and to bring early warning of alterations in the environment that might specify undesirable effects (Burger, 2002). Wetland bird's populations may provide as sentinel species for natural and anthropogenic pollution problems in the surroundings.

Major foraging grounds of these birds were paddy fields, river banks, ponds, and other water sources, but now these birds are getting adapted to garbage dumps in towns, waste water canals etc. Increase in food source (insects, bugs and worms) may have attracted these birds to garbage.

In this study it was mainly focused on there any impact of water quality on *Ardeola grayii*, it was observed that, it is fish loving bird, and fishes are found in lake, pond, agriculture field, and small ditches, but if there was not life supporting requirement of fishes in water so there was very few or almost fishes absent in that feeding sites as a result *A. grayii* had to skip that site for feeding or shifted foraging behaviour. In urban area due to lack of water bodies or if available choked by garbage and get contaminated so there was no life support for aquatic organism as a result *Ardeola grayii* shifting their dependency on water bodies to garbage or dumped area, where it can get insects, worm, and bugs. But in rural area there was water bodies available so *Ardeola grayii* mostly observed near lake, pond or agriculture field for foraging, there was less disturbance, prey easily available, no polluted water and their number was maximum than urban areas.
In this study it is observed that, water quality affect behaviour of *Ardeola grayii* and their population in any feeding habitats, we should know the importance of water bodies and wading birds for ecosystem and food chain, we should try not to dumped garbage in water bodies, it importance not only for wading birds but also for fishes and other invertebrates which live in water bodies and all those are play important role in maintaining a food chain.

Shrinkage of water surface, decrease in salinity and fishery resources, introduction of invasive fresh water aquatic weeds is the greatest threats to the lake. An overall loss of biodiversity with decline in productivity adversely affecting the livelihood of the community.

CONCLUSION

Ardeola grayii is mostly depend on water body for their life activities, this studies data suggests that, day by day shrinkage of water body and deterioration of water quality increasing so in coming days aquatic birds will come under threatened condition. In this study the feeding habitat of *A. grayii* exhibits low DO, high BOD and COD, total hardness and higher level of concentration of metal level. So it faces threats to the habitats and sites on which they depend for feeding, breeding and resting purposes. In this study it was observed that they shift their habitats but in city area most of the wetlands deteriorating so if wetlands will be not maintained *A. grayii* may comes under threatened category. These birds are indicator of healthy environment, so protection, management and conservation of wetland require so that birds can also save from extinction.

Acknowledgement
Authors thanks to all who helped in sampling and lab work, and also thanks to Uttar Pradesh Pollution Control Board for their valuable suggestion.

Conflict of Interest
The author(s) declare(s) that there is no any conflict of interest

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