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Monsoon associated macroinvertebrate community dynamics in lakes of urban and semi-urban areas of Ranchi, North Eastern India.

Dinámica de la comunidad de macroinvertebrados asociada al monzón en lagos de áreas urbanas y semiurbanas de Ranchi, noreste de India.

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ABSTRACT

In Indian subcontinent monsoon affects billions of lives, even modest alterations in spatiotemporal pattern may lead to significant socioeconomic stress in the region. Monsoon also affect creation, rejuvenation, and sustenance of lakes. Freshwater lakes habitats various biological assemblages that translates in ecological quality of water. During monsoon, heavy inflow of runoff water can significantly alter species assemblages and their association with quality of water. This study evaluated changes in macroinvertebrates dynamics of Ranchi (urban) and Kanke (semi-urban) lakes located in Chota Nagpur Plateau, North-eastern India. Results indicated higher abundance of macroinvertebrate in Ranchi lake than Kanke lake. However, taxa richness was greater in Kanke lake in comparison to Ranchi lake. Monsoon had higher impact on abundance of taxonomic order under family Gastropoda. Post-monsoon increase in abundance of Basommatophora (14%), Neotaenioglossa (14%), and Littorinimorpha (13%) were observed. Likewise, Architaeniogiossa, incertae sedis, Haplotaxida were least affected taxonomical orders during investigated seasons. Both lakes were dominated by collector-gatherers (CG), however, Kanke lake indicated richness in diversity of FFGs. CGs were also less motivated by seasonal alteration before, during and after monsoon. In conclusion, pre-monsoon, monsoon and post-monsoon seasons largely affects abundance of macroinvertebrates in both lakes. Runoff rainwater supports macroinvertebrate development through addition of nutrients. This study indicated that Ranchi lake contains high abundance of scrapers (SC) and grazers (GZ), those are associated with higher anthropogenic activities. Likewise, higher taxonomical richness in Kanke lake indicated more diverse and healthy ecosystem.

Keywords: Monsoon, Macroinvertebrates, Functional Feeding Groups, Freshwater lakes.

RESUMEN

En el subcontinente indio, el monzón afecta a miles de millones de vidas, incluso las alteraciones más modestas en el patrón espaciotemporal pueden provocar un estrés socioeconómico significativo en la región. El monzón también afecta la creación, el

rejuvenecimiento y el sustento de los lagos. Los lagos de agua dulce albergan varios ensamblajes biológicos que se traducen en la calidad ecológica del agua. Durante el monzón, la fuerte afluencia de agua de escorrentía puede alterar significativamente los ensamblajes de especies y su asociación con la calidad del agua. Este estudio evaluó los cambios en la dinámica de los macroinvertebrados de los lagos Ranchi (urbano) y Kanke (semiurbano) ubicados en la meseta de Chota Nagpur, en el noreste de la India. Los resultados indicaron una mayor abundancia de macroinvertebrados en el lago Ranchi que en el lago Kanke. Sin embargo, la riqueza de taxones fue mayor en el lago Kanke en comparación con el lago Ranchi. El monzón tuvo un mayor impacto en la abundancia del orden taxonómico bajo la familia Gastropoda. Se observó un aumento posterior al monzón en la abundancia de Basommatophora (14 %), Neotaenioglossa (14 %) y Littorinimorpha (13 %). Asimismo, Architaeniogiossa, incertae sedis, Haplotaxida fueron los órdenes taxonómicos menos afectados durante las temporadas investigadas. Ambos lagos estaban dominados por recolectores-recolectores (CG), sin embargo, el lago Kanke indicó riqueza en diversidad de FFG. Los GC también estaban menos motivados por la alteración estacional antes, durante y después del monzón. En conclusión, las estaciones premonzónicas, monzónicas y posmonzónicas afectan en gran medida la abundancia de macroinvertebrados en ambos lagos. El agua de lluvia de escorrentía apoya el desarrollo de macroinvertebrados mediante la adición de nutrientes. Este estudio indicó que el lago Ranchi contiene una gran abundancia de raspadores (SC) y herbívoros (GZ), los cuales están asociados con actividades antropogénicas más altas. Asimismo, una mayor riqueza taxonómica en el lago Kanke indicó un ecosistema más diverso y saludable.

Palabras clave: Monzón, Macroinvertebrados, Grupos Funcionales de Alimentación, Lagos de agua dulce.

INTRODUCTION

Monsoon is a natural phenomenon, in which Inter-Tropical Convergence Zone moves from northeast to south and southwest causing reversal of winds leading to northeast rainy season. Billions of lives in Indian subcontinent depend on monsoon rain, slightest change in period of arrival and/or retreat can bring natural catastrophes in the subcontinent. Monsoon in India has greater impact on livelihoods of people, as it affects farming, and framing related industries. Besides, monsoon precipitation paly significant role in vegetation in India (Sarkar and Kafatos, 2004). Previous studies have mentioned that observation of vegetation in an area can effectively characterize the regional weather (Anyamba et al., 2014; Zhang et al., 2015). Similarly, most lakes in India are either formed or maintained through monsoon precipitations. Surface water temperature of lakes changes significantly during pre-monsoon season, and water level reduce remarkably. This leads to change in rates of chemical reaction (Stumm and Morgan, 1996), and rates of metabolic processes (Allen et al., 2002; Gillooly et al., 2001; Kraemer et al., 2016) causing an imbalance in aquatic ecosystem. The same occurs in opposite direction during post-monsoon season, thus, a dynamic change in the invertebrate communities of lakes occurs during the period of pre- to post-monsoon.

Rain water is one of the main contributors in lakes, thus, it plays important role in lake ecosystems. Slightest change in monsoon precipitation can have greater impact on physicochemical properties of water in lakes (Lal and Lal, 2021). The temporal variation in the availability of food affects life-cycle of aquatic consumers. Both quantity and quality of food is overstressed by the extreme variation in seasons (Junker and Cross, 2014).

Based on annual precipitations invertebrate communities greatly fluctuate. Previous study indicated that voltinism among macroinvertebrate varies according to multiple factors such as; latitude, altitude and external influence (Shama et al., 2011). During unfavourable conditions, aquatic insects may enter diapause to survive. However, reactivating from diapause depends on the environmental cues to resume growth (Bale and Hayward, 2009). Therefore, real-time unambiguous presence of macroinvertebrate in lakes can predict alterations made by seasonal influence to the ecosystem.

Lakes at low altitude are not only fresh water reservoir but can also act as indicators of alterations in weather (Fureder et al., 2006). Level of nutrients in these lakes varies according to localization, this leads to specific characterization of lakes into oligo- or eutrophic. Therefore, aquatic vegetation in these lakes are also highly diversified. Presence of vegetation allows effective propagation of macroinvertebrates in an aquatic ecosystem. These macroinvertebrates are divided based on their functional feeding groups (FFG) such as; shredders, collector-filterers, collector-gatherers, grazers and predators (Allan, 1995). Availability and types of food in low altitude lakes greatly affects numbers and communities of macroinvertebrates. The present study was conducted in city of Ranchi, located in north eastern India. Geographically, it lies near to the tropic of cancer (23°22'N 85°20'E), sun can be observed directly overhead during June solstice. Ranchi district lies at an average elevation of 651 m above sea level and located within the Chota Nagpur plateau.

Alterations in the seasonal intensities could be potential reason behind change in numbers of FFG of macroinvertebrates. Previous studies have noted that besides monsoon precipitations change in numbers of FFG's are also contributed by latitudinal gradients, altitude and environmental stress. Therefore, in this study an attempt was made to evaluate dynamics of macroinvertebrates across pre-, during-, and post-monsoon seasons in lakes of Ranchi area. FFGs are more sensitive towards environmental surroundings, thus, locations of lakes were selected based on density of localities (urban and semi-urban).

MATERIALS AND METHODS

Sample site: Two lakes Kanke (23.4018 N, 85.3126 E) and Ranchi (23.3684 N, 85.3181 E) were selected for the study located at semi-urban and urban areas of Ranchi, Jharkhand, India, respectively (Figures 1-2). Drainage area of Kanke lake catchment is 6-10 km^2 within south-western, southern and south-eastern area. Most area of drainage are heavily populated and maintained by Ranchi Municipal Corporation (RMC), Ranchi. Riparian zone around the lake is approximately 50 m and mostly dominated with heath and/or meadow. Number of trees in the area are moderate, most of these deciduous. Similarly, drainage area of Ranchi lake is approximately 3-5 km^2 of densely populated area. Seasonal rainfall runoff from local areas (north, north-eastern and eastern localities) and regular municipal sewage discharge are the main source of water in the lake. Riparian zone is unvegetated and surrounded by 30 ft bituminous road.

Collection of samples: Three sites were selected from each lake to investigate macroinvertebrate communities during three distinct periods. Macroinvertebrate were collected from three locations designated as T1, T2, and T3. Samples were collected on 12.05.2020, 12.07.2020, and 12.09.2020, based on seasons pre-monsoon, monsoon and post-monsoon, respectively. At these sites macroinvertebrate samples were collected through Surber sampler of size 0.05 m^2 with a mesh size of 500 µm. Largest substrata within the Surber sampler frame were scrubbed into a container, later, poured through

sampling net. Bottom of the lake was agitated to almost 2-4 cm deep for 1-2 minute, later benthic materials were captured by net and transferred into 1 lt bottle and preserved in 96% ethanol. These sites were further analysed during each season i.e. pre-monsoon, monsoon and post-monsoon.

Figure 1: Kanke lake also known as Kanke dam located northwest of the city. Densely populated at the eastern and southern-side. Highlighted terrain indicates catchment area for inflow (southwestern-side) and outflow (northern-side) discharge channels in to Jumar river.

Figure 2: Ranchi Lake located at the centre of the city, flanking regions are densely populated. Lake is surrounded by roadways all through its edges. Source of water is run through rain water and city sewage discharge.

Analysis of samples: Samples were filtered to exclude coarse and fine material through 4 mm sieve and 63 µm sieve, respectively. The coarse materials were discarded and macroinvertebrates were picked carefully. For picking macroinvertebrates from fine sieve, samples were magnified (X10) under a microscope. Following sorting of macroinvertebrates samples were preserved in 96% ethanol in clean glass vials. Taxonomical identifications were carried out based on methods Nilsson (1996) and Nilsson (1997).

Statistical analysis: The abundance was measured by calculating sampling area (0.05 m^2) at each site. Values were measured in Mean±SD, *P* variation lower than 0.05 was considered significant. Abundance was measured through taxa richness and overall abundance in each lake during period of investigation. Alterations in community composition over period of investigation for both lakes during each season and respective distance from existing FFGs were visualized through metric multidimensional scaling (MDS) (MS-EXCEL v16, US). Lower than 0.2 stress value is considered good fit for variables represented in 2D (Clarke and Warwick, 2001). Pie chart was drawn for actual percentage of FFG communities in both lakes during each season. Likewise order of macroinvertebrate was used to signify its presence in the lakes based on seasonal deviations.

RESULTS

Abundance: Significant alterations in abundance (ind/m^2) of macroinvertebrate were observed during period of investigation. An increasing trend was visible through transition from pre-monsoon to monsoon and from monsoon to post-monsoon in Kanke lake, overall abundance was noted as 2600-4933-6333 ind/m^2 (Figure 3A). Whereas, macroinvertebrate abundance in Ranchi lake declined significantly and constantly through pre-monsoon to monsoon to post-monsoon, which was noted as, 13066-6500-3900 ind/m^2 (Figure 3B). Comparatively, Ranchi lake indicated higher macroinvertebrate abundance with respect to Kanke lake during all three seasons.

Taxa richness and community constituents: Wide spectrum of communities was present in both investigated lakes. Nearly similar number of order of species were present i.e. 13 in Kanke lake and 12 in Ranchi lake, nevertheless, overall number of number of species was higher in Kanke lake comparing to Ranchi lake (Tables 1-2). These species were further segregated based on functional feeding groups into collector-gatherers (CG), collector-filterers (CF), grazers (GZ), predators (PR), scrappers (SC), and shredders (SH). Results indicated that number of CG group of species were higher in both lakes comparing to other FFGs. However, Ranchi lake inhabited more CGs (79%) than Kanke lake (53%). Number of FFGs were lower in Ranchi lake (4) comparing to Kanke lake (6). Significantly higher number of SCs were present in Kanke lake (29%) comparing to Ranchi lake which constituted to only 7% SCs of the total FFGs. Result showed exclusive presence of GZs (10%) and CFs (2%) in Kanke lake with respect to Ranchi lake (0%) (Figure 4A-4B).

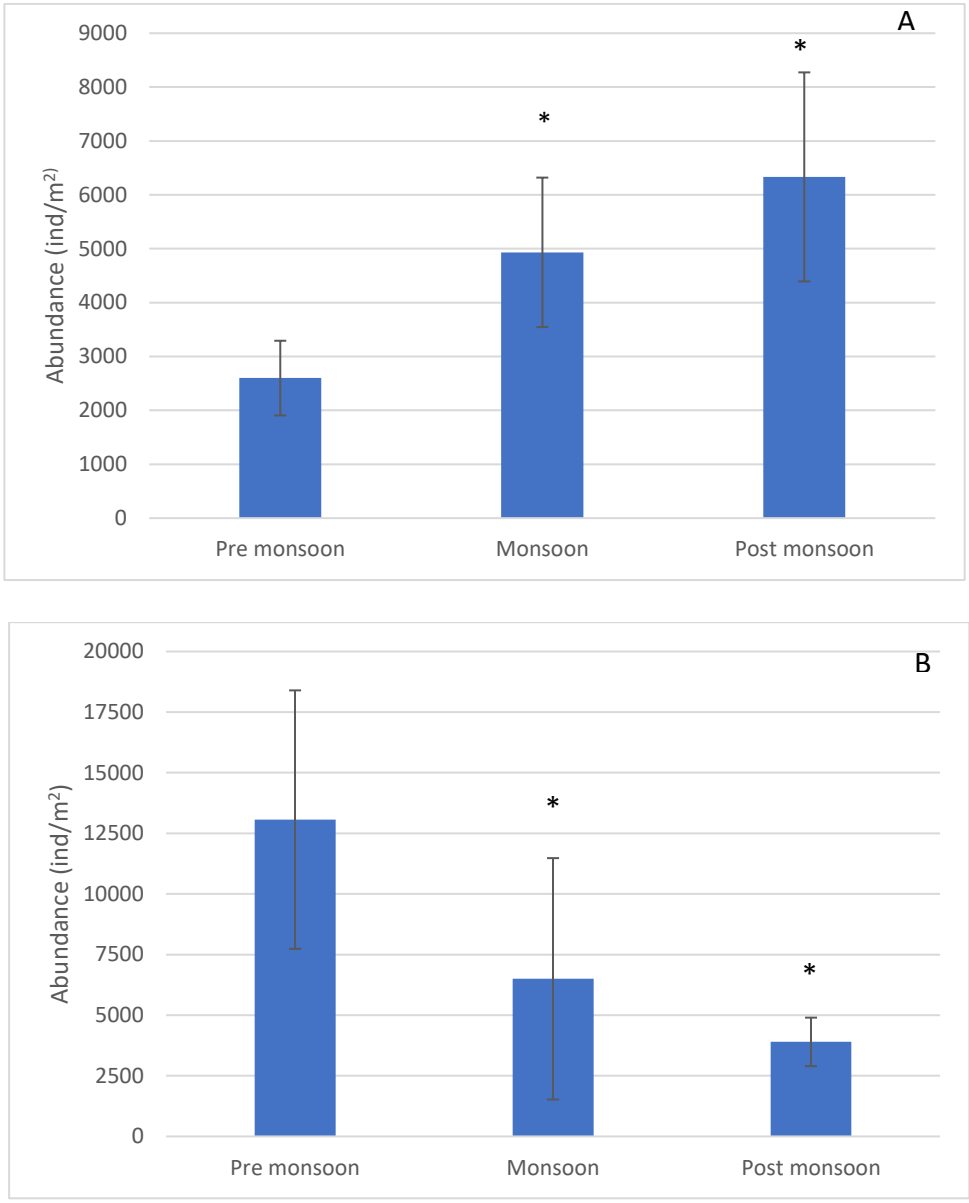

Figure 3: Macroinvertebrate abundance during pre-monsoon, monsoon and post-monsoon seasons in Kanke lake (A) and Ranchi lake (B).

*P>0.05 (Variation was measured against preceding seasonal abundance) .

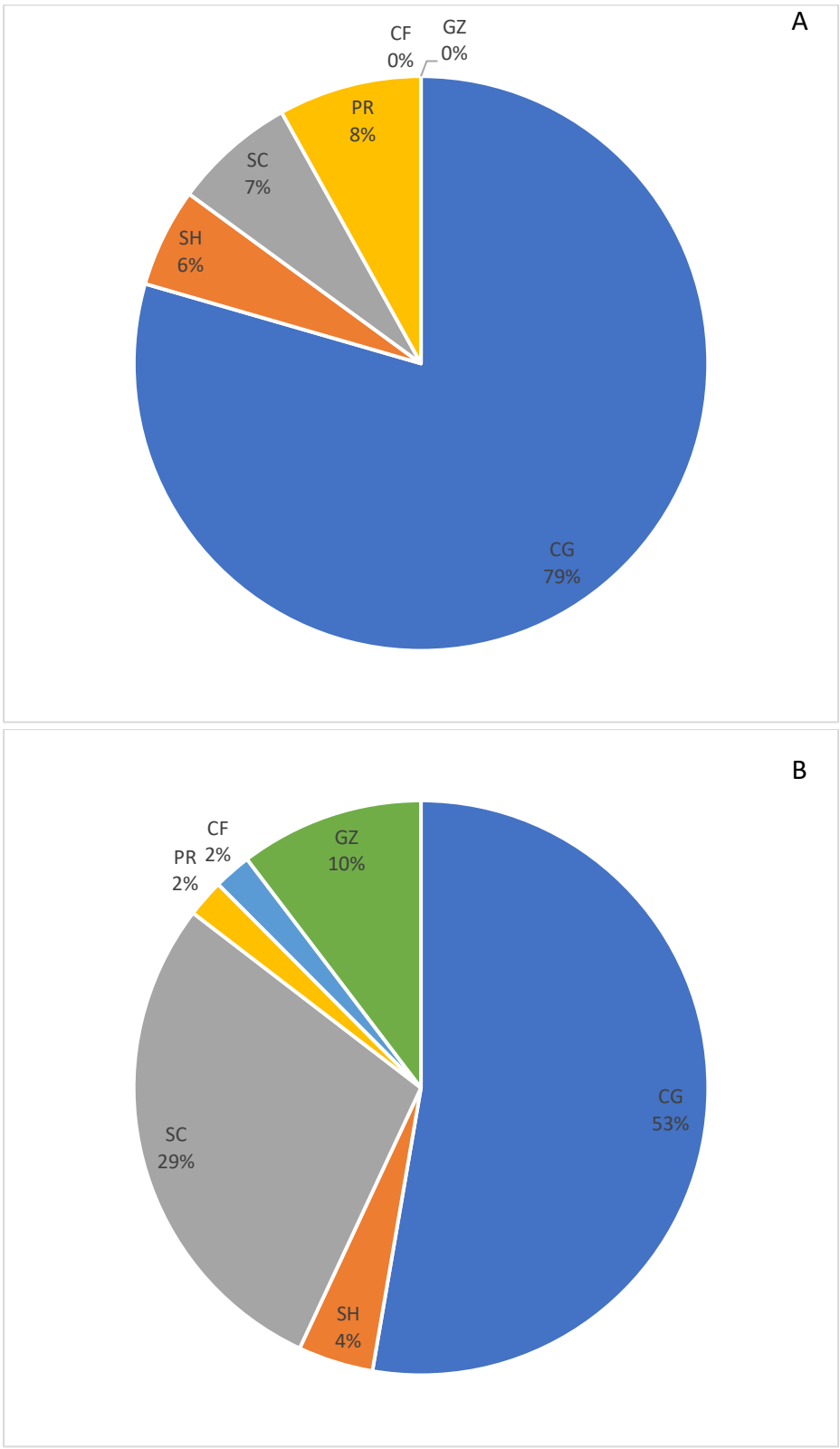

Figure 4: Percentage coverage of FFGs in Ranchi lake (A) and Kanke lake (B) during complete period of investigation.

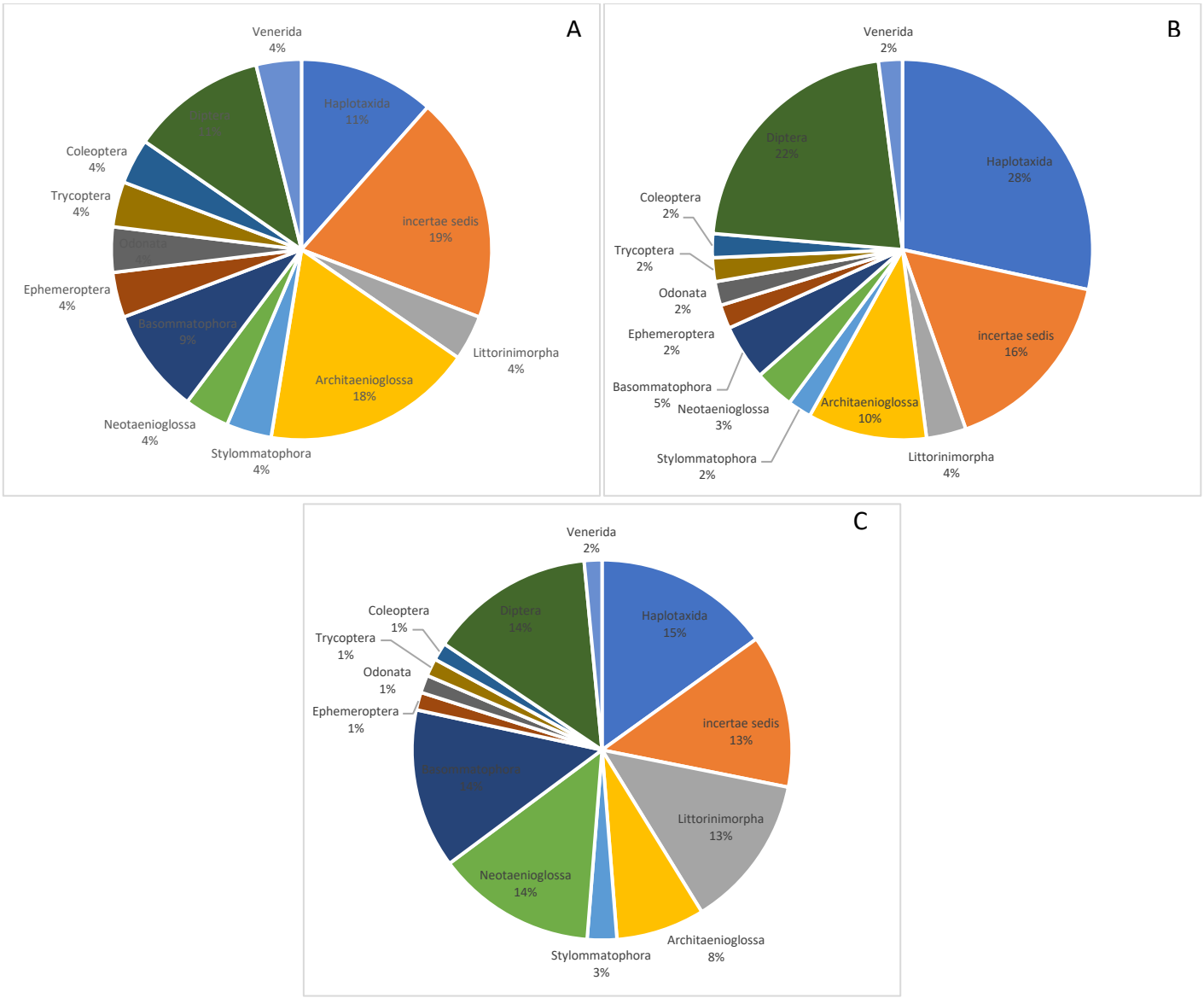

Figure 5: Taxonomic order dynamics of macroinvertebrate in Kanke lake during pre-monsoon (A), monsoon (B), and post-monsoon (C).

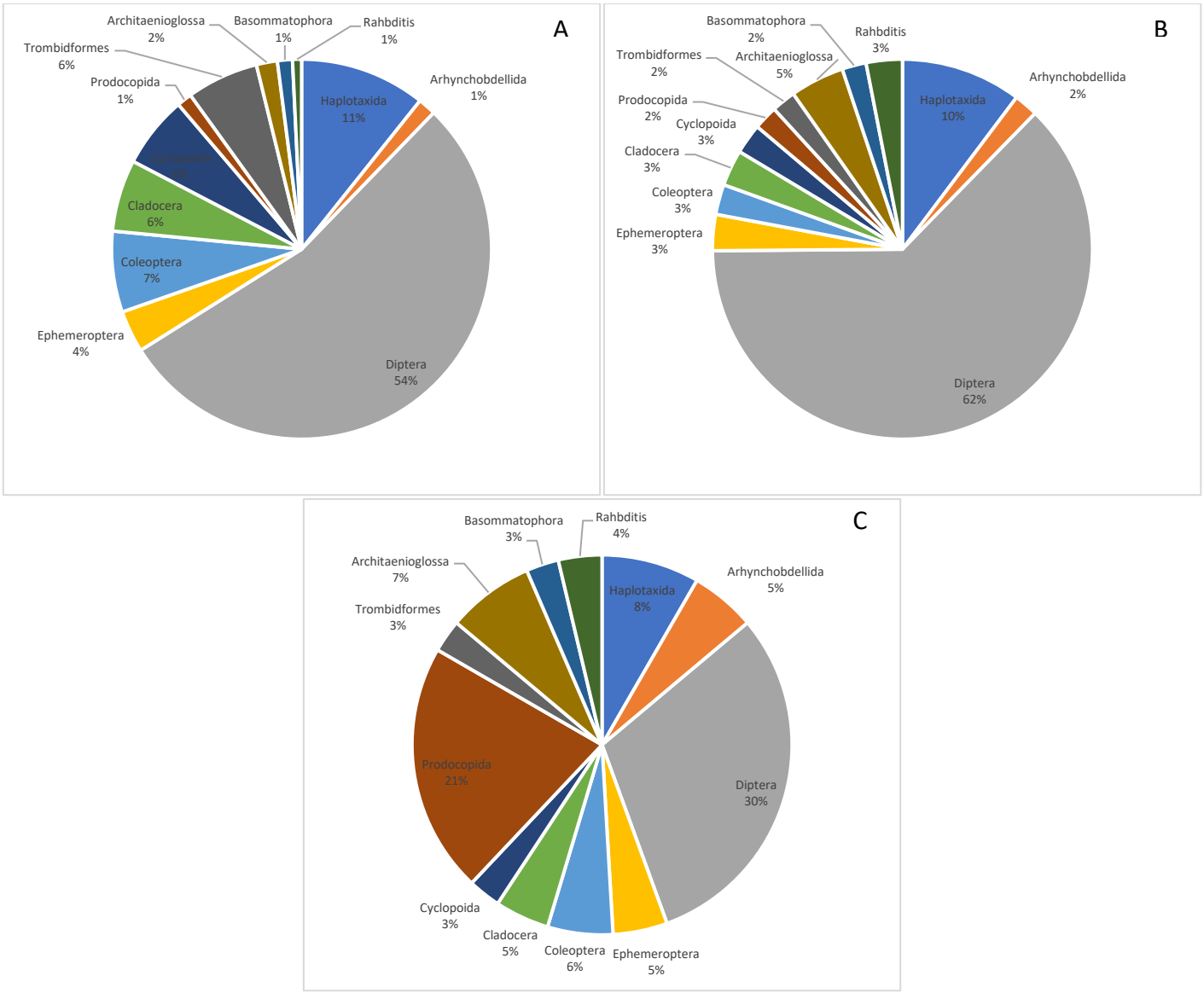

Figure 6: Taxonomic order dynamics of macroinvertebrate in Ranchi lake during pre-monsoon (A), monsoon (B), and post-monsoon (C).

Table 1: Family and orders of species found in Kanke lake during pre-monsoon, monsoon and post-monsoon seasons.

Family	Order	Species
Clitellata	Haplotaxida	*Tubifex tubifex*
		Limnodrilus udekemianus
		Limnodrilus angustipenis
		Limnodrilus hoffmeisteri
		Potamothrix vejdovoski
		Aulodrilus omericanes
		Dero obtura
		Dero pectinate
		Chaetogaster sp
		Pristina sp
		Brastislvia bilongata
	incertae sedis	*Aeolosoma*
Gastropoda	Littorinimorpha	*Diagoniostoma cerameopoma*
		Gobia orscula
	Architaenioglossa	*Vivipara bengalensis*
	Stylommatophora	*Helix sp*
	Neotaenioglossa	*Thiara tuberculata*
		Thiara scobro
	Basommatophora	*Indoplanorbis exustus*
		Gyraulus convexiusculus
Insecta	Ephemeroptera	*Ephemera sp*
		Ephemerella sp
		Caenis sp
	Odonata	*Anisoptera*
		Zygoptera
	Trycoptera	*Cheumatopsyche sp*
		Rhyacophila sp
	Coleoptera	*Stenocolus sp*
		Gyrinus sp
	Diptera	*Limnophila sp*
		Chironomus sp
		Glyptotendipes sp
		Polypedilum sp
		Dicrotendipes sp
		Coelotanypus sp
		Procladius sp
Bivalvia	Venerida	*Corbicula fluminea*

Table 2: Family and orders of species found in Ranchi lake during pre-monsoon, monsoon and post-monsoon seasons.

Family	Order	Species
Clitellata	Haplotaxida	*Nais communis*
		Dro indica
		Stylaria foscularis
		Aulophorus hymanae
		Branchiodrilus sempere
		Chaetogaster langi
		Aelosoma bengalensis
	Arhynchobdellida	*Hirudinaria javoniea*
Insecta	Diptera	*Chironomus sp*
		Ceratopogen sp
	Ephemeroptera	*Caenis perpusilla*
		Laccophilus chinensis
	Coleoptera	*Eretes sticticus*
Branchiopoda	Cladocera	*Hydrophilus indicus*
Hexanauplia	Cyclopoida	*Cyclops sp*
Ostracoda	Prodocopida	*Cypris sp*
Arachnida	Trombidformes	*Hydrachna kloomi*
		Pila globose
Gastropoda	Architaenioglossa	*Lymnaea luteala*
	Basommatophora	*Indoplanorbis exustus*
Secernentea	Rahbditis	*Rahbditis sp*

Seasonal influence on community dynamics: Monsoon greatly affected taxa richness in both investigated lakes. Variation in availability of taxonomic order were predominantly found in Kanke lake (Figure 5). Major taxonomic order of macroinvertebrate in Kanke lake were Architaeniogiossa, incertae sedis, Haplotaxida, and Diptera, throughout periods of investigation. Regardless, variation in individual taxa were significant when compared with each passing season. Relative abundance of Architaeniogiossa, incertae sedis, Haplotaxida, and Diptera during pre-monsoon season was 18%, 19%, 11%, and 11%, respectively, which altered substantially during monsoon to 10%, 16%, 28% and 22%, respectively. Later during post-monsoon season abundance of major taxonomic orders in Kanke lake were noted as 8%, 13, 15%, and 14%, respectively. Exclusive increase in numbers of Basommatophora (14%), Neotaenioglossa (14%), and Littorinimorpha (13%) were highlight of post-monsoon change in community dynamics, these three taxonomic orders indicated at least 5-10% surge comparing to monsoon and pre-monsoon seasons (Figure 5A-5C). Remaining taxonomic orders remained unmotivated by monsoon precipitation and post-monsoon.

Likewise, major taxonomic order in Ranchi lake were Haplotaxida and Diptera. Abundance of both taxonomic orders were similar during pre-monsoon and monsoon, which was recorded as 11% and 10% for Haplotaxida and 54% and 62% for Diptera, respectively. Remaining taxonomic orders of macroinvertebrate were limited to 30-35% of total compositions during pre-monsoon and monsoon. Significant change in macroinvertebrate dynamic was witnessed during post-monsoon in Ranchi lake. Results

indicated that abundance of Prodocopida during post-monsoon season was 21% comparing to relatively lower abundance during pre-monsoon and monsoon, which was recorded as 1% and 2%, respectively. Although number of taxa within Haplotaxida and Diptera remained high comparing to other taxonomic orders, however, significant decline in individual abundance was observed comparing to pre-monsoon and monsoon (Figure 6A-6C). Residual taxa constituted for nearly 40% of total composition, these were largely unaffected by pre-monsoon, monsoon and post-monsoon.

Metric multidimensational scaling (MDS) analysis: Distance matrix between FFGs and lakes during pre-monsoon, monsoon and post-monsoon were investigated through ordination plot of MDS. The R^2 value of MDS was observed within acceptable limit (R^2=0.600). Maximum map distance was observed for CG against both lakes and other FFGs (Figure 7). Results indicated that CG was at maximum distance from Ranchi lake during pre-monsoon season (PR-R), whereas, minimum map distance was noted from Kanke lake during pre-monsoon (PR-K). Minimum distance was observed between Kanke lake during monsoon season and CF, followed by Ranchi lake during post-monsoon season and CF. Similarly, Ranchi lake during pre-monsoon season and GZ were close on the distance map. Kanke lake indicated similar distance between each season and PR, SH, and SC FFGs, where PR being the closest and SC furthest. Overall, based in dissimilarity index Kanke lake during all investigated seasons indicated least distance from FFGs (excluding CG) comparing to Ranchi lake. Nonetheless, Ranchi lake during post-monsoon season reflected similar pattern to that of the Kanke lake and were observed least distant from FFGs (excluding CG) comparing to Ranchi lake during pre-monsoon and monsoon seasons (Figure 7).

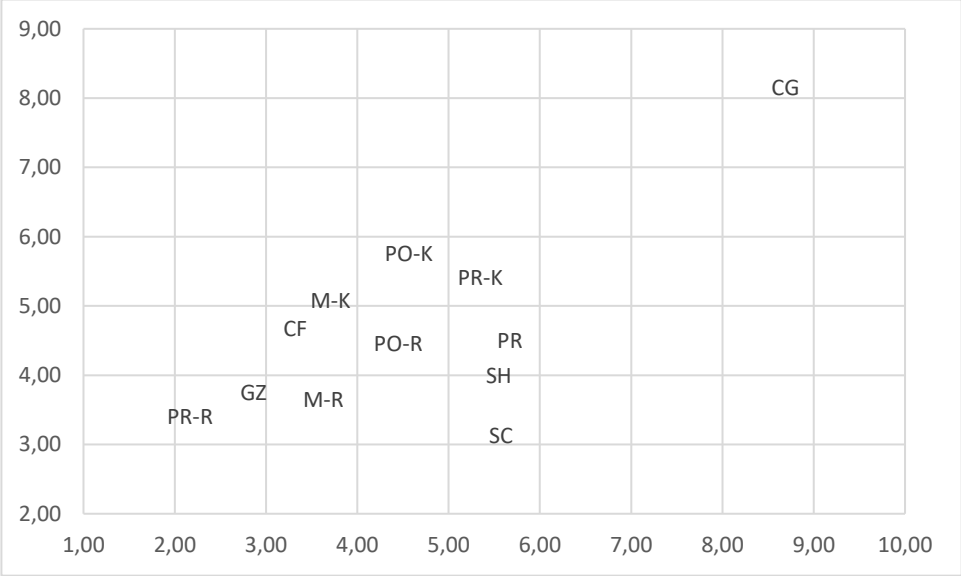

Figure 7: Metric multidimensional scaling (MDS) ordination plot of distances between FFG communities (CG, GZ, CF, PR, SH, SC) and investigated lakes during pre-monsoon (PR-K, PR-R), monsoon (M-R, M-K) and post-monsoon seasons (PO-K, PO-R).

DISCUSSION

World is facing an unprecedented weather pattern. Just recently Canada broke all previous records of high temperature, marked as exceptional heat dome. According to BBC (BBC World News, published on 1st Jul 2021), heatwave stayed for more than three

days at 49.6 C in Lytton, British Columbia, Canada. Many weather experts predict more such intense weather pattern in future. Across the world, water environment and aquatic surroundings are facing similar challenges. Besides global warming and climate change, human interferences such as loading of nutrients and air pollution have increased significantly, causing severe surface water acidification (Arnell et al., 2015). Climate change affects aquatic ecosystem through changes in water quantity and quality. Indian monsoon plays important role in sustenance of freshwater lakes. Previous studies have mentioned that composition of particulate organic matter in lakes can significantly change based on amount of precipitation (Gaedke, 1992; Bunn et al., 2003; Lau et al., 2014). During rainy season, large amount of allochthonous carbon is added to the lakes, which greatly affects the aquatic system (Gu et al., 2006). Likewise, earlier during summer and subsequent to monsoon aquatic ecosystem faces multiple stresses, which lead to presence and propagation of season specific taxonomical species. This study attempted to investigate alterations in macroinvertebrate communities and its compositions during summer, monsoon and following its retreat.

Aquatic worms are common freshwater inhabitants, these oligochaetes are generally found in soft sediments containing rich organic matter. This study found at least 12 species under order Haplotaxida in Kanke lake throughout investigated seasons. The group increased substantially during monsoon and later declined partially during post-monsoon. Previous study has reported significant rise of worms during rainy season (Bayon and Binet, 1999). During summer reduced water level increases littoral zone allowing more dry area around the lake. Significant richness of Haplotaxida during monsoon could be due to worms reveal themselves from borrows due to heavy rain and thus, can be easily found at test sites of Kanke lake. Despite slight increase in relative abundance of Haplotaxida, it was a common taxon constituent during pre- and post-monsoon. Richness of species under this order was greater in Kanke lake comparing to Ranchi lake.

This study also noted constant presence of incertae sedis during all three inspection periods regardless of extreme heat and rainfall. A study by Kumar and Thomas (2019) reported that presence of incertae sedis can adopt to high rainfall during monsoon and temperature during summer. This study noted differential nutrient requirement by incertae sedis during summer and monsoon. It was reported by the authors that high concentration of ammonia and phosphate influence growth of incertae sedis, where the earlier found in abundance during summer and later during monsoon. Kanke lake indicated significant increase in relative abundance of taxonomic order Littorinimorpha from pre-monsoon season to post-monsoon, which is primarily a sea snail but can be found in freshwater lakes also. This could be due to higher activity of snails during rainy season as it causes heavy irrigation of the trees and shrubs (Odongo-Aginya et al., 2008). Relatively higher abundance of Littorinimorpha during post-monsoon in Kanke lake could be due to humid warm temperature led hatching of eggs. Where substantially higher richness of family gastropoda was noted in Kanke lake (30-50%), relative abundance of species under this family was only 3-7%. Snails are important for healthy aquatic ecosystem, as it affects the growth of submerged macrophytes by removing epiphyton from surface of aquatic plants (Cao et al., 2014). Lower relative abundance of family gastropoda in Ranchi lake is indicative of inadequate aquatic diversity.

Another important taxonomic order diptera showed specific abundance within investigated lakes, that altered significantly under influence of monsoon. This group of insects play important role in an aquatic ecosystem while their larvae are free-living and

crawl/swim actively in the surrounding. As the larvae capture particulate organic matter and process in the benthos (Courtney and Merritt, 2009). These larvae are constituents of nearly every FFGs. Interestingly, nearly 46000 species under diptera are connected with aquatic environment and one of the major drivers of ecosystem. Result of this study showed nearly 7 species under order diptera in Kanke lake in comparison to merely 2 species in Ranchi lake. Seasonal influence on abundance of this order indicated significant dependence on monsoon. An 10% increase in abundance was noted when Kanke lake transited through pre-monsoon to monsoon. Later, nearly 8% decline in abundance was observed as the lake transited from monsoon to post-monsoon. Temperature plays important role in development of aquatic insects (Arnold, 1959; Wagner et al., 1984a; Wagner et al., 1984b; Higley and Peterson, 1994), as during high temperatures dipteran larvae reduce the development time by increasing frenetic activity and fast metabolism (Campobasso et al., 2001). Which means high temperature increase the rate of development in dipteran, it goes against our finding where during monsoon highest abundance of dipteran were observed. There could be two possible reasons for this 1) during Indian monsoon temperature remains high until rainfall, following spells of rainfalls temperature again surge with excessive humidity, and 2) types of species studied under this taxonomical order could have been different in referred study, thus, developmental data may vary.

Ephemeroptera is an equally important order under family insecta, it provides essential services to aquatic ecosystem such as; bioturbation, bio-irrigation, decomposition, food for other aquatic species, cycling of nutrients and spiralling in lakes (Jacobus et al., 2019). In general, ephemeroptera is referred to mayflies, however, it is not true as other insect such as dayflies, shadflies and fishflies also come under this taxonomic order. During their mass emergence, they swarm in hundreds of square kilometres, when adult can survive for few minutes (Edmunds et al., 1976; Corkum, 2010; Reynolds et al., 1979). According to a study by Perng et al. (2007) emergence of ephemeropteran peaked in early summer and then decline sharply during monsoon. This study showed similar pattern in Kanke lake for abundance of ephemeropterans. Abundance of ephemeroptera declined by 2% during each season in sequence of pre-monsoon, monsoon and post-monsoon. Similar results were observed in Ranchi lake, at least 1% decline in abundance was observed during monsoon comparing to pre-monsoon.

Function feeding groups (FFGs) of macroinvertebrates provide ample information on quality of aquatic ecosystem. High fluctuation and low similarity in FFGs composition related to closely located sites or anthropogenic activities. There specific presence may suggest quality of water in the lakes. For example, locations close to effluent discharge sites show dominance of scrapers and grazers, suggesting surge in nutrients and algal growth (Echelpoel et al., 2018). Results of this study showed high abundance of scrapers and grazers in Ranchi Lake which accounted for nearly 40% of total FFGs. Ranchi lake is surrounded by densely populated localities, sewage discharge in lake is huge concern for local municipalities. It confirms finding of this study that reciprocate to high abundance of scrapers and grazers in Ranchi lake. On contrary, the relative abundance of scrapers in Knake lake was only 7% and no grazers were found to exist during period of investigation. Kanke lake is located in a semi-urban area where most of its littoral zone fall into non-encroached empty land. This study confirms that presence of FFGs can define quality of water in lakes. Abundance of collector-gatherers in both lakes were extremely high, results of this study showed least seasonal influence on their richness. MDS ordination plot clearly indicated less dependence of collector-gatherers on pre-monsoon, monsoon and post-monsoon seasons in both investigated lakes. According to Vannote et al. (1980) CGs are

utilized riparian zone as source of allochthonous material. They acquire particulate organic matter from interstices in sediments, thus, they are least affected by environmental temperature (Bediako, 2021). This confirms findings of this study that abundance of CGs are less dependent on seasonal influence during pre-monsoon, monsoon and post-monsoon.

In conclusion, most macroinvertebrates are affected by extreme seasonal alterations during pre-monsoon, monsoon and post-monsoon. Their abundance varies significantly during dry season and wet season. Surrounding human encroachment also affects relative abundance of macroinvertebrate. This study finds higher taxonomic richness in Kanke lake with respect to Ranchi lake. Most abundant taxa in Kanke lake were Haplotaxida, incertae sedis, and architaenioglossa. These taxonomic orders were also least motivated by seasonal influence before, during and after monsoon. Likewise, high abundance of dipteran was found in Ranchi lake, which remain highest among other taxa despite seasonal influence. Highly motivated taxonomic order was from family Gastropoda, significant increase in abundance of species was observed during post-monsoon season. Dynamics of FFGs in both lakes revealed that CGs are least affected due to seasonal influence. Whereas, other FFGs were closely related to extreme alteration in weather pattern during pre-monsoon, monsoon and post-monsoon seasons.

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