Original Research Article

A Study of Phytoplankton and Zooplankton Diversity Inthe River Sabarmati, Gujarat, India.

Abstract

Abiotic and biotic components are divided into two categories to describe the structural ecosystem. Aquatic plants and animals can find a suitable habitat in the river's water body. Planktons are an important component of the wetland ecology and may serve as a marker of altering water quality. Zooplankton mostly obtains its nutrition from phytoplankton, an ecosystem producer. Most fish larvae and other plankton-eating fishes feed primarily on zooplankton species. All aquatic ecosystems' dynamics revolve around primary productivity, which sustains various food chains and food webs. An important measure to evaluate the level of pollution in aquatic ecosystems is now the size and dynamics of primary production. The overgrowth of macrophytes, pesticides from agricultural runoff, household garbage, sewage sludge, feces near rivers, bathing of domestic animals, washing of clothing and utensils, etc. have all put pressure on river ecosystems over the past many years. Most plants and animals struggle to survive in polluted environments, but those that can handle the stress of pollution on their own may be able to. These creatures can serve as pollution indicators, or more particularly, as bioindicators of the ecosystem's trophic condition. In aquatic wetlands, plankton variety is crucial. The Sabarmati River's phytoplankton and zooplankton communities were evaluated at six different locations. The current investigations were researched from January 2017 to December 2019 over a period of around 3 years. Several published plankton manuals were used for plankton collection and identification.

Keywords: *Biodiversity, Phytoplankton, Zooplankton, River Sabarmati, Ecosystem*

I. Introduction

The freshwater ecosystem includes rivers, ponds, lakes, puddles, pools, and swamps, as temporary or permanent water bodies. The structural ecosystem is classified into two types of abiotic and biotic components[1]**.** Abiotic components include pH, light, temperature, oxygen levels, etc., and biotic components include plants, animals, and decomposers [2].The primary water source controls variousenvironmental factors and associated plants aswell as animal life [3].Water is used by the community for a variety of purposes, including aquaculture, washing dishes, agriculture, and animals. The rivers provide habitat, food, water, and a breeding ground for a variety of native species, including dragonflies, frogs, birds, and other creatures[4].The river water bodyprovides a suitable habitat for aquatic plantsand animals. Many invertebrates are dependenton these dead and decaying organisms, whicheventually become a part of the food chain [5].Planktons play a significant role in the wetlandecosystem and are a potential indicator ofchanging water quality. They are susceptibleto ecological conditions and react promptly toadjust to the environment [6].Phytoplanktons are the primary producers of any aquatic habitat, they float passively in water surface and sometimes, they may extenddown to various depths where light is available for photosynthesis. Phytoplanktons, include green algae, blue green algae, diatoms, desmids, euglenoids etc., are important among the aquatic floras. They are ecologicallysignificant as they form the basic link in thefood chain of all aquatic animals, and when inlarge numbers they make the water greenish[7], Several, physico-chemical factors[8] and varyinginflux conditions can markedly influence the aquatic system,and cause changes in the phytoplanktonabundance, diversity, and succession.Phytoplankton, aprimary producer of the ecosystem, is a majorfood source for zooplankton. Zooplanktonspecies are the initial prey for most fish larvaeand other plankton-eating fishes[9].In case of blooms or scum, Cyanobacteria pose a series of problems for water quality, fisheries resources, agriculture, and human health. The planktonic algae contribute substantial amount of dissolved oxygen in the aquatic systems [10]. Micro algae are indeed the biological starting point for energy flow in the food chain in most aquatic ecosystemsand gives information relating to the amount of energy available to support bioactivity of the system.The dynamics of all aquatic ecosystems centre around primary productivity for supports different food chain and food webs. The magnitude and dynamics of primary production has become an essential parameter to assess the state of pollution in aquatic ecosystems. For the last many years, river ecosystemhas beenunder pressure due to overgrowth ofmacrophytes, pesticides from agriculturalrunoff, domestic waste, sewage sludge,defecation around rivers, bathing for domesticanimals, washing clothes, and utensils, etc [11]. In polluted environment majority of plants and animals find it difficult to survive but those which could tolerate the stress of pollution alone may survive. These individuals can act as indicator of pollution, more specifically bioindicators of the trophic state of the ecosystem[12].

II. Material and Methods

2.1 Preparation for Sampling

At least one day before sampling, it was made sure that all the arrangements are made asperthe check list. It was also made sure to know how to reach sampling location(s). Help with maps and landmarks was extensively taken before ensuring proper location. For eachsampling location, on the pre-decided sampling procedure the sampling checklist wasprepared and accordingly the preparation was done. It was always safer to carry a fewnumbers in excess.

2.2 Sampling Procedure

The objective of sampling is to collect a portion of water from the water body small enoughin volume to be conveniently transported and handled in the laboratory, while stillaccurately retaining its representatively. This implies that the relative proportions orconcentrations of the components of interest should be the same in the samples when theyare being analyzed, as they were originally in the river or drain. River water samples were collected from the well mixedzone at all the river locations at an appropriate depth. The samples were collected in the morning hours between 8.00 to 10.00 am. The samples collected were transportedcarefully to the laboratory (Life Science Department, School of Sciences of Gujarat University, Ahmedabad& GujaratPollution Control Board (GPCB) laboratory) through vehicle, where samples were analyzed as per the APHA and other standard criteria.

2.3 Sampling duration

The samples were collected during a three-year study period from Jan 2017 to Dec 2019.

2.4 Collection of flora (phytoplankton) and fauna (zooplankton)

Biological assessment of water quality has its own advantages compared to the traditionalphysicochemical monitoring. The Central Pollution Control Board has underlined thesignificance of biological parameters, especially biomonitoring using benthic macroinvertebrates in integrated evaluation of water quality. Benthic macro invertebratesare the best indicators for bio-assessment. The abiotic environment of the water body directly affects the distribution, population density and diversity of the macro benthiccommunity. Benthic fauna is especially of great significance for fisheries that theythemselves act as food of bottom feeder fishes**.** The littoral region is animportant interface between land and pelagic zone of water body. Rooted plants, micro and macro-invertebrates and demersal fish species occupy it. Macrozoobenthic organisms playan important role in the energy cycle of fresh-water bodies. Their value as indicatororganisms of water quality and occurrence with relation to sedimental particle size werehighlighted in several reports **[13].** Ateach location, the sampling area was approached starting from downstream towards upstream.

2.5 Collection of phytoplankton and plants

From each site the floating and submerged plants were collected and were brought to thelaboratory for their identification. The identification of such plant matter was done usingstandard keys. The phytoplankton material was collected by filtering 10 liters of watersamplethrough fine mesh net several times to obtain sufficient study materials. Theplanktonic matter was transferred to Lugol's Iodine Solution for preservation. In thelaboratory such saturated planktonic matter was mixed with 50 ml water and centrifugedat different speeds to get stratified phytoplankton matter. The phytoplankton-wereidentified using identification monograph and APHA volume.

2.6 Collection of zooplankton

Zooplankton were collected by a conical fine mesh net. A net made from 20-micron nylonmesh of 2 ft. was used for collection of Zooplankton. The collection of plankton was doneby allowing flow of water to pass through this net at surface and sub surface. The materialwas collected in a plastic bottle and preserved by 10% formalin. The analysis ofidentification of zooplankton using standard reference and optical microscope was carriedout in the laboratory.

2.7 Drop count method

The samples were gently but thoroughly shaken, and a small drop was placed immediatelyon a micro slide and covered with a cover glass. One end of the cover glass was focusedunder microscope and after a careful scanning of species and its number, the slide wasshifted to next field and preceded parallel to first observation in reverse direction.Depending on the density further dilution was made and zooplankton was counted andfinally an average was calculated.

Number of a species per liter = A X 1/L x N/V

Where, A = Number of organisms per drop

L = Volume of original sample (25 1)

N = Volume of concentrated sample (100 ml)

V = Volume of one drop (0.1 ml)

2.8 Quantification studies

Quantitative analyses were carried out from same samples to study the density of various fauna. This is finally represented as the number of animals per liter of water sample.

Figure-1 sampling sites for the collection of phytoplankton and zooplankton.

III. Results and Discussion

An ecosystem is a dynamic relationship between abiotic and biotic parameters. Everyparameter has its dependence on each other. Abiotic factors largely control the biotic environment of any ecosystem. Here in this riverine ecological work along with abioticfactor, i.e., the water, biotic factor in the form of biodiversity analysis is carried out. Thebiotic component is elaborately analyzed for phytoplankton, aquatic flora, zooplankton, andother fauna.

3.1 Floral Component

Phytoplankton are a diverse group of photoautotrophic microorganisms which are theprimary producers of any aquatic ecosystem. The phytoplankton populations in diversehabitats are highly responsive to changes in available environmental conditions of thehabitat. The nature and distribution of phytoplankton varies considerably with respect toseasons and water quality. Their dominance also leads to qualitative changes to aquaticsystems. Information pertaining to the nature, type and distribution of these organisms providesclues regarding the environmental conditions prevailing in their habitat **[14].** Phytoplankton populations in lotic systems like rivers, springs, and openoceans are highly dynamic in nature with variability in response to changes in seasonalenvironmental conditions. A variety of ecological processesregulate phytoplankton assemblages and abundances in natural systems **[15].**The phytoplankton community on which the whole aquatic population depends islargely influenced by the interaction of severalphysico-chemical factors**[16].** Aquatic flora analyzed here in two respects i.e., phytoplankton and aquatic vegetation or aquatic weeds. Phytoplankton wererepresented by four groups, viz. Bacilariophyceae, Chlorophyceae, Cyanophyceae, andEuglenophyceae. Diversity study reveals common planktonic forms present at differentsites of sampling. In general, aquatic weeds like Hydrilla, Valesneria, Chara, Nymphea,Pistia, Typha etc. were commonly found in the study area. To know the nature of speciescomposition of phytoplankton and their significance, the present observations were madefor the period of three years at six selected locations during 2017-2019. The occurrence ofphytoplankton species during the study was summarized in the table below for six study areasrespectively.

Table-1 Occurrence of different phytoplankton at Sabarmati River

Typeof phytoplankton	Generarecorded	S-1	S-2	S-3	S-4	S-5	S-6
Bacilariophyceae (Diatoms)	Asterionella	-	+	+	+	-	-
	Cosinodiscus	+	+	+	+	+	+
	Cymbella	-	+	+	-	-	-
	Fragilaria	+	+	-	-	+	+
	Navicula	+	+	-	-	-	-
	Melosira	+	+	-	-	-	-
	Rizosolenia	+	+	-	-	-	-
	Synedra	-	+	+	+	+	+
	Pinnularia	+	+	+	+	+	+
Chlorophyceae (Greenalgae)	Chlorella	+	+	-	-	-	+

	Spirogyra	+	+	-	-	+	+
	Eudorina	+	+	-	-	+	+
	Pediastrum	+	-	-	-	+	+
	Pandorina	+	+	-	-	+	+
Cyanophyceae (Blue-greenalgae)	Anabaena	+	+	-	-	+	+
	Microsystis	+	+	-	-	+	+
	Glaeotricnia	-	-	-	+	+	+
	Trycodesmium	+	+	-	-	+	+
	Oscillatoria	+	+	-	-	-	-
Euglenophyceae	Euglenaacus	-	+	-	-	+	+
	Phacuslongicauda	+	-	-	-	-	-
	Euglenasp	_	+	-	-	+	+

Table-2 List of the commonly occurring Hydrophytes (Aquatic weeds)

Typeof hydrophytes	**Generarecorded**	**S-1**	**S-2**	**S-3**	**S-4**	**S-5**	**S-6**
Freefloating plant	Eichomiacrassipes	+	+	-	-	+	+
	Lemnapaucicostata	+	+	-	-	+	+
Submerged plants	Hydrillaverticillata	+	+	-	-	+	+
	Otteliaalismoides	+	+	-	-	+	+
	Potamogetonspp.	+	+	-	-	+	+
	Vallisneriaspiralis	+	+	-	-	+	+
Emergentplants	Polygonumglaqbrum	+	-	-	-	+	+
	Typhaangustata	+	-	-	-	+	+
	Sagittariasagittifolia	+	-	-	-	+	+

3.2 Faunal Component

Along with a variety of plant matter in an aquatic ecosystem, diversity of aquatic animals alsois of great importance. This floral and faunal diversity together maintains the ecosystem inbalance. The faunal component is represented by several different aquatic animals.Zooplankton presence makes the main representation of fauna. However, other varieties ofanimals from invertebrate and chordata groups are of equal importance as diversitycomponent. Ichthyofauna and lather economically important animals represented hereestablishes a link between ecological and economical exploration of the riverine ecosystem.

3.3 Zooplankton

Zooplankton are tiny animals that feed on phytoplankton and other zooplankton. Theyoccupy a central position between the autotrophs and other heterotrophs and form animportant link in food web of the freshwater ecosystem. Protozoa,Cladocera, Copepoda and Rotifers are the main groups of zooplankton found in freshwater bodies. Among the zooplankton, Rotifers are apparently the most sensitive indicators of water quality [**17].**A fewvarieties representing differentgroups of animals were denoted as miscellaneous groups. The annual average percentage ofzooplankton from different sites revealed different forms in their density attributed to water quality. Arthropods were represented by a variety of copepods and calanids. Despite their small size, they are important in the aquatic food web because of their abundance, distribution, and wide range of feeding habits. Copepoda and Cladocera are largerzooplankton and members of the class Crustacea. Among Cladocera, Daphnia (the common"water flea"), is probably the most recognizable zooplankton. Zooplankton is a goodindicator of changes in water quality because it is strongly affected by environmentalconditions and responds quickly to changes in environmental quality. The stability ofzooplankton in any aquatic body of water is of profound importance because they serve asa unique food source for fish and many other aquatic vertebrates **[18].**Zooplankton plays an integral role and serves as bio indicators and is a well-suited tool forunderstanding water pollution status. According to Wardle D.A. et al.,most of the zooplankton prefer either the steady or the low water current habitat.Among planktonic diversity, phytoplanktonic diversity is greater in proportion thanzooplankton diversity. The distribution of zooplankton community depends on several factors such as change of climatic conditions, physical and chemical parameters, andvegetation cover**.** Hence, qualitative, and quantitative assessments ofzooplanktons are of great importance**[19].**

3.4 The Riparian Fauna

A comprehensive checklist of riparian fauna could have been very long and material for doctoral work. Despite all enthusiasm this work was restricted only to themostcommonly occurring invertebrate faunal species. Six Molluscans and sixteenArthropods were identified to be the most commonly occurring riparian fauna.

3.5 The Planktonic Fauna

The river Sabarmati is a habitat for a large variety of aquatic fauna, representing the fauna otherthan classified as zooplankton. The diversity of such animals' spreads among theinvertebrates to vertebrates among small sized animals' variety of larval forms of majorphylarepresentatives were also recorded. Vertebrate forms were abundantly represented asfishes. Several varieties of commercially economical and non-commercial varieties of fish were found in the waters of Sabarmati. The tadpole larvae of frogs were commonly observedin the water near the sand area. To know the nature of species composition of zooplanktonand their significance, the present observations were made for the period of three years atsix selected locations during 2017-2019. As described in the Materials and Method section thesamples were analyzed for quantification of various zooplankton. Primarily density ofzooplankton in terms of no./l was estimated for individual species of various phyla. Thesedata were subjected to various analyses for proper understanding of the planktonic diversityand distribution within the entire stretch of the study area. The overall zooplankton densitywas noted to be higher at Site-1 as compared to other sites. During months of monsoon andin some cases winter, the density of some Protozoans was extremely high and therefore thetotal zooplankton densities noted within these months were also conspicuously high ascompared to that on any other season during the study period. Analysis interms of density of all the zooplankton further indicated decrease in density during summerseason.

Table-3 List of major riparian fauna.

PhylumMollusca	Bithyniasp.

	Corbiculasp.
	Glessulasp.
	Limacinasp.
	Planispirasp.
	Planorbissp.
PhylumArthropoda	Camponatussp.
	Cocinellasp.
	Culex sp.
	Coliassp.
	Danussp.
	Forcipulatasp.
	Gyrinussp.
	Halobatessp.
	Myrmicariasp.

3.6 The collective density of zooplankton at various study sites

The annual values of all zooplankton showed greater densities at site-1 and site-6 followedby other sites, respectively. When the data were analyzed for contribution of each phylumto the overall zooplankton densities, it was dominated by Protozoa and Arthropodsthroughout thestudy period. This was followed by Rotifera, Annelid and Nematoda,respectively (Values are Mean ± SE)

Table-4 Year wise collective density of all zooplankton at different study sites

Year	Site-1	Site-2	Site-3	Site-4	Site-5	Site-6
2017-18	1425.2±113.4	1135±120.3	640±90.1	642±81.6	712±92.5	758±92.7
2018-19	1390.4±120.8	1108±117.4	616±86.8	622±82.1	702±95.9	739±97.2
2019-20	1407.6±110.5	1125±115.8	627±89.1	631±88.3	721±97.3	753±96.4

Table-5 Phylum wise yearly average density of zooplankton at Site-1

	Year	Protozoa	Nematoda	Rotifera	Annelida	Arthropoda
	2017-18	722.1±80.4	32.4±3.8	61.9±8.3	17.2±3.1	520.3±60.3
Site-1	2018-19	680.4±71.3	45.3±4.2	68.2±9.1	25.3±2.2	541.2±62.6
	2019-20	710.2±82.9	40.8±7.1	66.3±7.9	22.5±3.5	537.6±60.8

Table-6 Phylum wise yearly average density of zooplankton at Site-2

	Year	Protozoa	Nematoda	Rotifera	Annelida	Arthropoda

	2017-18	684.1±70.2	29.1±3.1	58.8±7.5	13.5±2.2	531.5±60.6
Site-2	2018-19	550.6±61.1	39.5±4.7	53.1±8.2	24.6±1.8	550.3±61.4
	2019-20	650.4±72.7	42.3±5.2	62.7±7.7	23.8±2.9	540.3±62.2

Table-7 Phylum wise yearly average density of zooplankton at Site-3

	Year	**Protozoa**	**Nematoda**	**Rotifera**	**Annelida**	**Arthropoda**
	2017-18	155.2±71.1	12.2±2.7	18.7±2.5	13.5±2.7	131.9±6.2
Site-3	2018-19	153.8±65.4	15.5±2.2	21.2±1.2	17.9±2.1	140.1±7.4
	2019-20	146.7±71.1	20.4±1.7	20.4±2.5	16.3±1.9	150.6±7.2

Table-8Phylum wise yearly average density of zooplankton at Site-4

	Year	**Protozoa**	**Nematoda**	**Rotifera**	**Annelida**	**Arthropoda**
	2017-18	156.2±70.4	13.4±1.9	19.9±1.5	17.7±2.1	133.3±5.1
Site-4	2018-19	150.8±65.7	15.8±2.8	23.4±2.5	19.3±2.6	142.3±6.2
	2019-20	148.7±70.2	21.4±1.5	22.6±2.9	18.6±2.3	148.4±6.5

Table-9 Phylum wise yearly average density of zooplankton at Site-5

	Year	**Protozoa**	**Nematoda**	**Rotifera**	**Annelida**	**Arthropoda**
	2017-18	161.4±62.2	17.5±3.6	28.3±3.2	17.3±3.3	142.8±8.1
Site-5	2018-19	165.8±63.8	20.6±3.8	25.7±7.1	22.8±3.6	148.3±7.4
	2019-20	169.6±68.8	24.5±2.9	28.1±5.5	24.5±2.9	156.9±7.8

Table-10 Phylum wise yearly average density of zooplankton at Site-6

	Year	**Protozoa**	**Nematoda**	**Rotifera**	**Annelida**	**Arthropoda**
	2017-18	176.9±41.4	39.3±4.1	72.6±7.9	37.1±2.8	179.6±9.4
Site-6	2018-19	181.1±43.5	51.9±3.6	65.5±8.4	32.3±3.7	174.8±8.9
	2019-20	188.4±46.7	48.7±3.8	68.9±8.1	34.8±3.1	171.9±9.1

3.7 Percentilecontributionofdifferentphylathroughtheentirestudyarea duringdifferent yearsof thestudy.

The percentile composition of protozoan fauna at six study sites suggested that on morethan half of the sampling occasions their major contribution was recorded at sites-1,2 and 6followed by sites 5, 4 and 3, respectively. However, on some occasions like change inseason the population densities of Protozoan species were comparatively higher at sites incomparison with other species. Thus, it may be stated that though a higher number ofprotozoan species is recorded at most of the sites, there are occasions when an indifferentpopulation distribution isseen atstudysites.

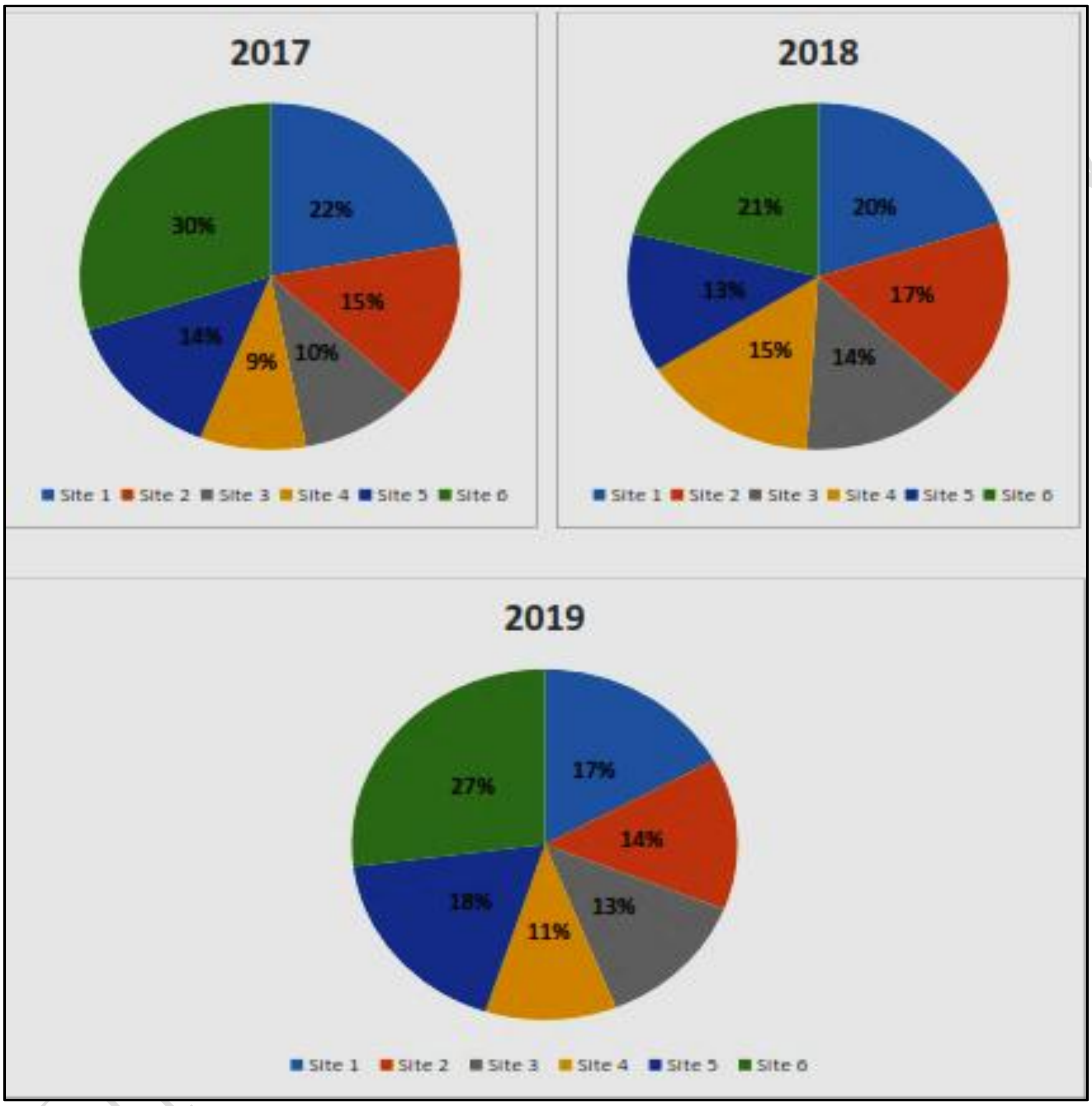

Figure-2PercentilecontributionofGroup-protozoathroughtheentirestudyareaduringdifferent years ofthe study

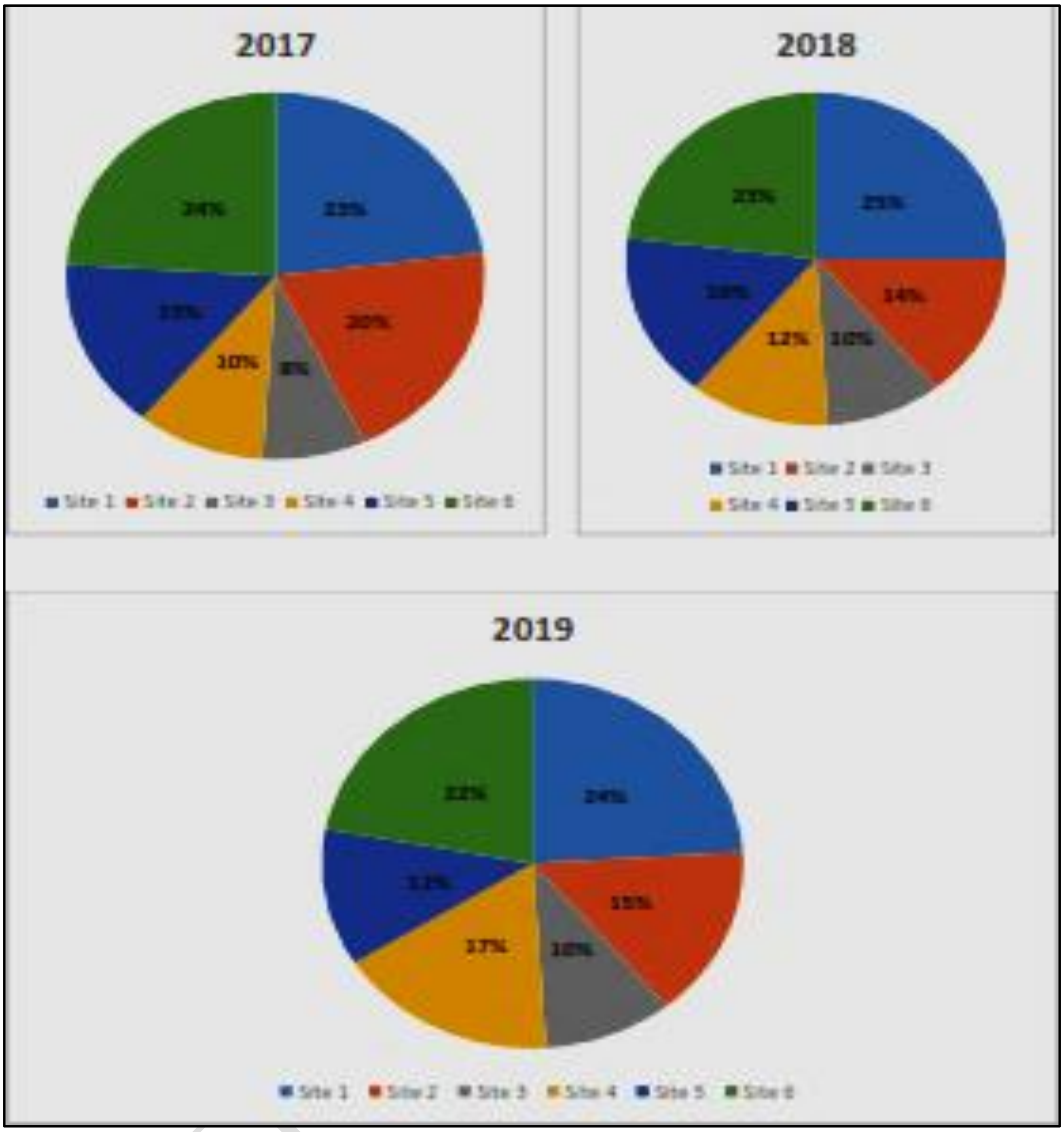

Figure-3 PercentilecontributionofGroup-Arthropodathroughtheentirestudyareaduring different years ofthe study

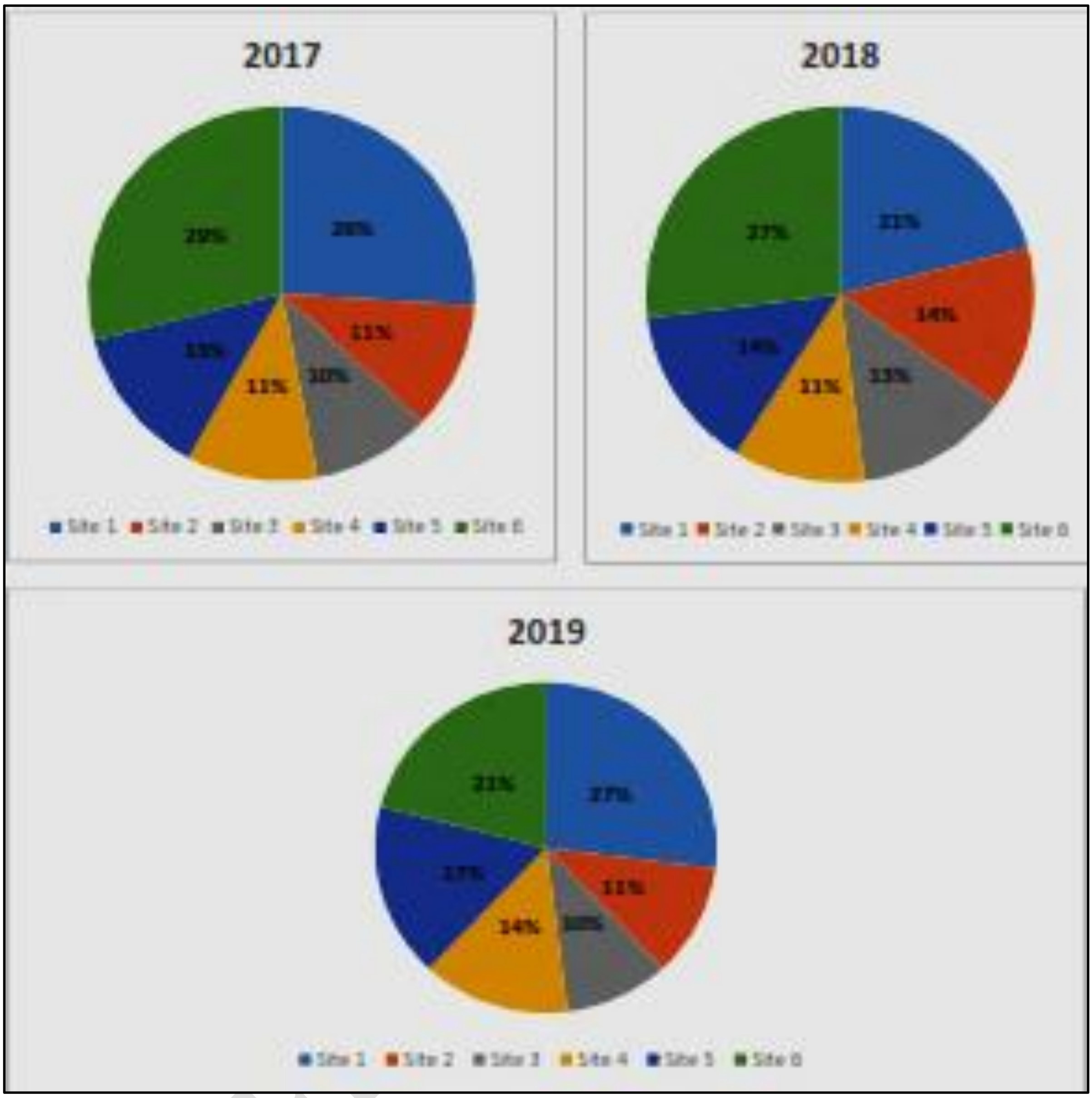

Figure-4 Percentile contribution ofGroup- Rotifera throughthe entire study areaduringdifferent years ofthe study

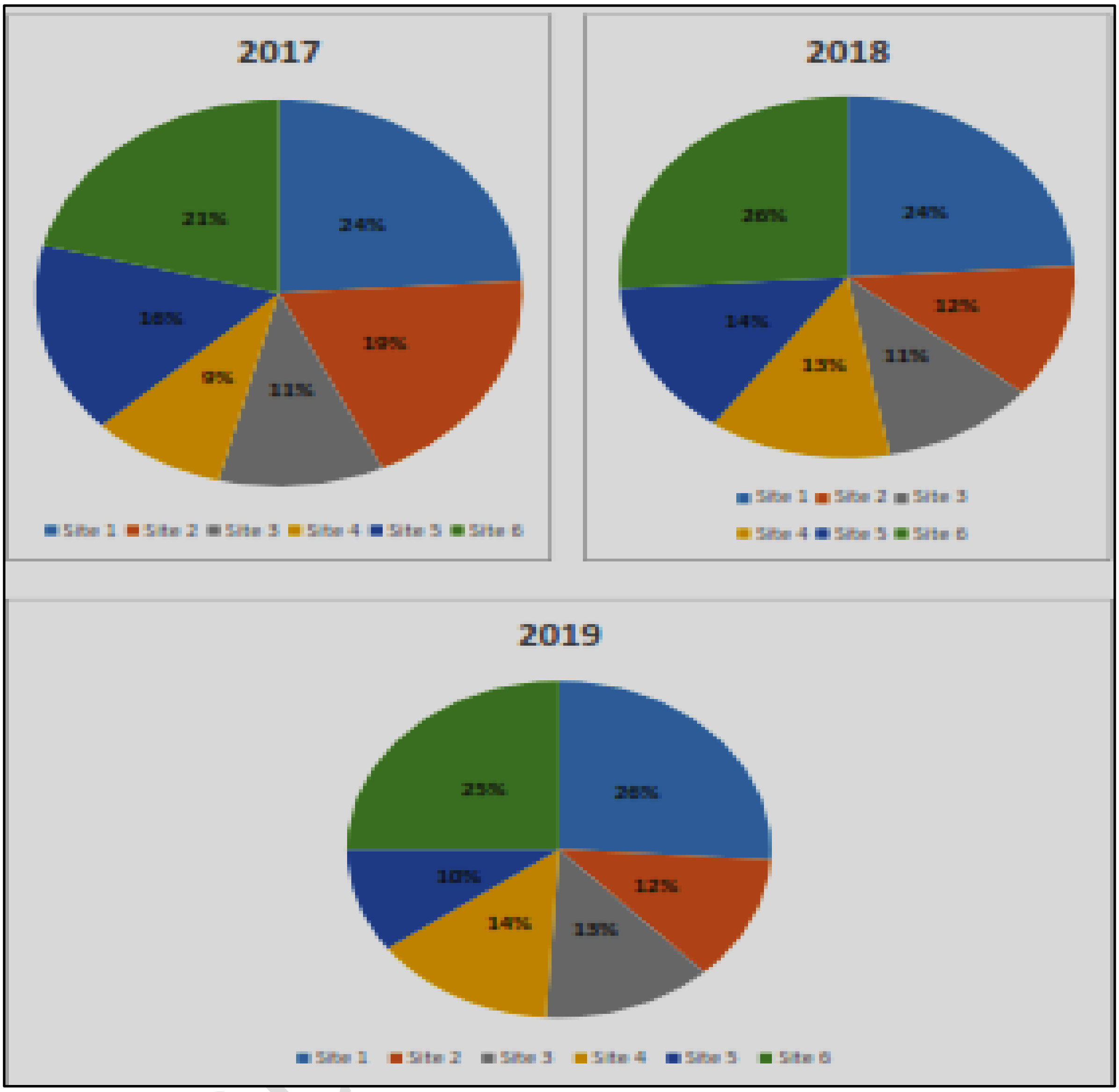

Figure-5 PercentilecontributionofGroup-Nematodathroughtheentirestudyareaduring different years ofthe study

The result described here showed thatthe mean abundance of phytoplankton inthe river Sabarmati was more and significantly different than the other river waterstudied.The low level of water, maximumanthropogenic activities, discharge of sewage,agricultural wastes, and other untreatedeffluents contamination, all of which enrichesthe nutrient level in the water, might be thereason for increased abundance of phytoplankton in the river Sabarmati. Similarly, Gadhia, et al., 2012**,** was reportedthat higher concentration of nutrient dischargecauses increased abundance of micro phytoplankton. Thephytoplankton showed significantpositive correlation with zooplankton**[20].**This implies, the micro zooplanktonrepresented the most important consumers ofphytoplankton production **[21].**Further, themean abundance of micro phytoplanktonshowed positive correlations with theabundance of particle bound bacteria and totalbacteria in the river Harangi, and with free living bacteria and total bacteria in the river.Bacterial utilization of organicmatter is significant in aquatic environmentsand its supply through phytoplankton **[22][23]**.Rainfall in the river Sabarmati showedsignificant negative correlations because highflow due to rain influences the increasedconcentration of turbidity in the water, which in turn reduces the phytoplankton productionand abundance. Micro phytoplankton plays a key role in maintainingproper equilibrium between abiotic and bioticcomponents of ecosystem.

IV. **Conclusion**

The world's rivers are the most productive ecosystem in terms of biodiversity because they create an environment that is conducive to the growth of both flora and fauna. Aquatic flora includes phytoplankton, which is a large part of the primary productivity that produces food for aquatic life. They serve as food for a variety of aquatic organisms, particularly fish and large invertebrates, and they are crucial to preserving the right balance between biotic and abiotic components of the aquatic ecosystem. The health of the water quality has been determined by phytoplankton, and these types of research serve as a baseline for future monitoring of a water body and are useful for conservation and management. Our understanding of the health and biodiversity of the aquatic ecosystem is aided by the current study's generation of fundamental data on the diversity of phytoplankton and zooplankton at a few chosen sites. Additionally, agroclimatic conditions in each area may have an impact on the presence or absence of genera or populations of plankton.

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