ASSESSMENT OF PHYTOPLANKTON DIVERSITY IN DIFFERENT DRINKING WATER SOURCES IN KATIHAR DISTRICT.

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Abstract : Drinking water is one of the prime necessities of life on the earth. Health of human beings are largely depends on the quality of drinking water used by them. Untreated or sometimes partially treated drinking water is often contaminated by hazardous chemicals, bacteria, phytoplankton, parasites etc. A large number of people especially rural and poor ones consume contaminated drinking water which is largely responsible for the ailments in them. Phytoplankton is one of the major causes of contaminations of drinking water quality. In the present investigation, an attempt has been made to evaluate the quality of drinking water by analyzing the status of phytoplankton in different drinking water sources of Katihar district. Phytoplankton density ranged from 00 to 07 OL^{-1} in tube wells water, 165 to 457 OL^{-1} in dug wells water, 00 to 09 OL^{-1} in railway supply water, 70 to 329 OL^{-1} in municipal supply water and 124 to 1259 OL^{-1} in river Ganga water. Total phytoplankton density was recorded maximum 1259 OL^{-1} in river Ganga water at Site-IV and minimum 00 OL^{-1} in tube wells and railway supply water at all the sites except tube well water at Site-II. Phytoplankton might be one of the major causes of drinking water problems and waterborne diseases in Katihar district.

***IndexTerms* - Phytoplankton, Drinking Water, Municipal supply, Railway Supply, River Ganga.**

I. INTRODUCTION

Investigation of phytoplankton is an important aspect in studying water quality of a water body [1]. In order to improve the water quality and to prevent the occurrence of water bloom, phytoplankton analysis is essential [2,3]. Phytoplankton are largely responsible for eutrophication of water bodies and contamination of drinking water. In recent decades, eutrophication has become one of the most serious environmental problems all over the world [4,5,6]. The algal bloom indicates that something is going wrong in the water body. Phytoplankton like land plants also require nutrients such as nitrate, phosphate, silicate and calcium at various levels depending on the species [7]. Some factors influencing phytoplankton growth also include quality and quantity of light [8], pH, hardness [9,10], salinity, turbidity, wind, toxic substances, heterotrophic microorganisms under pathogenic agents, carbon dioxide and water residence time [11]. Some species have also been associated with noxious blooms causing toxic conditions apart from the taste and odour problems. The quality and quantity of phytoplankton and their seasonal succession pattern have been successfully utilized to access the water abstraction, changes in natural food regime, land reclamation, pollution, over utilization of natural resource and poaching [12]. Phytoplankton bloom in drinking water leads to unpleasant taste and fishy odour in water and clog the filters [13]. Phytoplankton when pass from filters, change the colour and turbidity of water [14], create aesthetic problem and also serve as food for organisms in water pipes [15, 16]. Blocking and clogging of filters and corrosion of pipes are main difficulties in water supplies. Formation of slime creates bad effects to organisms. Some of the blue-green algae (*Microcystis*, *Aphanizomenon* and others) produce toxins which are poisonous to fish, cattle, sheep and other domesticated animals [17]. Consumption of water contaminated with cyanobacterial blooms causes gastrointestinal problems, tumours, haemorrhaging, dyspepsia, nausea, diarrhoea, abdominal pain, headache, pain in joints and muscles, burning skin, vomiting and even death [18,19]. Many biologists have reported the algal toxicity in human beings [20]. Toxins (microcystins) may act as tumour promoters and there are increasing evidences that these compounds may be more harmful in long term chronic exposure, such as low doses in drinking water, rather than short term acute exposure [21]. The cynotoxins (hepatotoxins and neurotoxins) produced by bloom forming cyanobacteria have been the cause of human and animal health hazards and even death [22]. The present study focuses on the analysis of phytoplankton of different drinking water sources viz. tube well, dug well, river Ganga, municipal supply and railway supply which are largely consumed by the people of Katihar district

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II. STUDY AREA

The phytoplankton of different drinking water sources from Katihar (Site-I), Manihari (Site-II), Amdabad (Site-III) and Barari(Site- IV) blocks of Katihar district were analysed. The drinking water samples were collected randomly from a number of tube wells, dug wells, railway supply, municipal supply and river Ganga in those areas and analysed during March 2010 to Feb 2012.

III. MATERIALS AND METHODS

Water samples of different drinking water sources were collected from different sites of selected area. Phytoplankton were isolated with the help of capillary pipette in Bold Basal Liquid Medium and subsequently transferred on agar plate by streaking technique [23]. The number of phytoplankton per litre was calculated from different drinking water sources. The photographs of

phytoplankton species were taken with the help of photographic microscope. The identification of phytoplankton was done with the help of relevant literature and monographs [24,25,26]

IV. RESULTS

4.1 Composition

Table 1: Algal Species Identified in Different Drinking Water Sources at Different Sites of Katihar District.

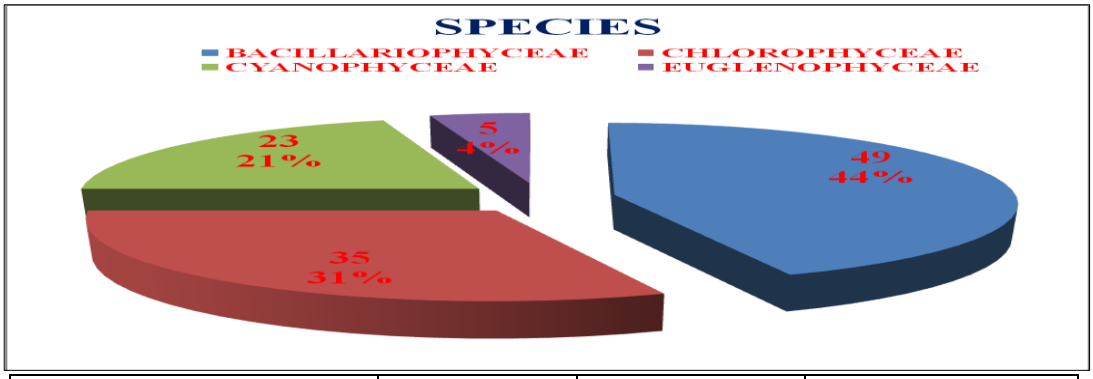
PHYTOPLANKTON	Site-I			Site-II					Site-III		Site-IV	
	TW	DW	RS	TW	DW	RS	MS	RG	TW	DW	TW	RG
Bacillariophyceae												
Achnanthes minutissima (Kuetz.) Grun.	-	-	-	-	-	-	-	+	-	-	-	+
Achnanthes affinis Grun.	-	-	-	-	-	-	-	+	-	-	-	+
Amphora acutiuscula	-	-	-	-	-	-	-	-	-	-	-	+
Caloneis silicula var. *tenuis* (Hustedt) Mayer	-	-	-	-	-	-	-	-	-	-	-	+
Caloneis sp.	-	-	-	-	-	-	-	-	-	-	-	+
Cocconeis hyppothea	-	-	-	-	-	-	-	-	-	+	-	+
Cocconeis placentula Ehr.	-	-	-	-	-	-	-	+	-	-	-	-
Cocconeis placentula var. *euglypta* (Ehr.) Grun.	-	-	-	-	-	-	-	+	-	+	-	-
Cyclotella meneghiniana Kuetz	-	-	-	-	+	-	-	+	-	-	-	-
Cyclotella glomerata Bachman	-	-	-	-	+	-	-	-	-	-	-	-
Cyclotella sp.	-	+	-	-	-	-	-	+	-	-	-	-
Cymbella tumida (Breb.) V.H.	-	+	-	-	+	-	+	+	-	+	-	-
Cymbella gracilis (Rabh.) Cleve	-	-	-	-	-	-	+	+	-	-	-	+
Cymbella aspera (Ehr.) Cleve	-	+	-	-	+	-	+	-	-	+	-	+
Fragilaria capucina var .*arctica* A. Cl.	-	+	-	-	+	-	+	-	-	+	-	+
Fragilaria capucina Desm.	-	+	-	-	-	-	-	+	-	+	-	-
Fragilaria pinnata f. subrotunda Mayer	-	-	-	-	+	-	+	+	-	+	-	+
Gomphonema sp.	-	+	-	-	+	-	-	-	-	-	-	-
Gomphonema sphaerophorum Ehr.	-	+	-	-	+	-	+	+	-	-	-	-
Gyrosigma baikleosis	-	-	-	-	-	-	-	-	-	-	-	+
Gyrosigma acuminatum (Kuetz.) Raph.	-	-	-	-	-	-	-	+	-	-	-	+
Hantzschia amphioxys (Ehr.) Grun	-	-	-	-	-	-	+	-	-	-	-	-
Hantzschia amphioxys var. *Pusilla* Dippel	-	-	-	-	-	-	+	+	-	-	-	-
Melosira granulate (Ehr.)Ralfs	-	-	-	-	+	-	+	+	-	+	-	+
Melosira granulate var. *mazzanensis* Meister	-	+	-	-	+	-	-	+	-	+	-	+
Melosira ambiguans (Brun.) Mull	-	+	-	-	-	-	-	-	-	-	-	-
Melosira islandica O.Mull	-	+	-	-	+	-	+	+	-	+	-	+
Melosira islandica var. *Helvetica* O.Mull	-	+	-	-	-	+	+	-	-	-	-	+
Navicula radiosa Kuetz.	-	-	-	-	+	-	-	+	-	-	-	+
Navicula cincta (Ehr.) Kuetz.	-	+	-	-	+	-	-	-	-	+	-	+
Navicula confervacea Kuetz.	-	-	-	-	-	-	-	+	-	+	-	+
*Naviculacryptocephala*var. *veneta*(Kuetz.) Grun.	-	-	-	-	+	-	-	+	-	-	-	+

Navicula mutica Kuetz.	-		-	-	+	-	-	+	-	+	-	-
Navicula densestriata Hustedt	-	-	-	-	-	-	-	-	-	-	-	+
Nitzschia amphibia Grun	-	+	-	-	+	-	-	+	-	-	-	-
Nitzschia obtuse smith	-	+	-	-	+	-	+	+	-	-	-	+
Nitzschia palea Kuetz	-	-	-	-	+	-	-	+	-	-	-	+
Nitzschia recta Hantzsch	-	-	-	-	-	-	+	+	-	-	-	+
Pinnularia acrosphaerica var. *minor* Cleve	-	-	-	-	-	-	-	+	-	-	-	-
Pinnularia conica Gandhi	-	+	-	-	-	-	-	-	-	-	-	-
Stauroneis kirtikari Gandhi	-	-	-	-	+	-	-	+	-	-	-	-
Stauroneis monota Krassake	-	-	-	-	+	-	-	+	-	-	-	-
Surirella linearis W. Smith	-	-	-	-	-	-	-	+	-	-	-	-
Surirella capronioides Gandhi	-	-	-	-	-	-	+	+	-	-	-	-
Surirella robusta f. minor Gandhi	-	-	-	-	-	-	+	-	-	-	-	-
Synedra acus var. *acula* Kuetz.	-	-	-	-	-	-	-	+	-	-	-	+
Synedra ulna (Nitz.) Ehr.	-	-	-	-	-	-	-	+	-	-	-	+
Synedra ulna var. *amphirhynchus* (Ehr.) Grun.	-	-	-	-	-	-	+	-	-	-	-	+
Synedra ulna var. *danica* (Kuetz) Grun	-	-	-	-	-	-	+	+	-	-	-	+
Chlorophyceae												
Actinastrum hantzschii Lagerheim	-	+	-	-	+	-	+	-	-	-	-	-
Actinastrum hantzschii var. *elongatum* Smith	-	-	+	-	-	-	+	-	-	-	-	+
Ankistrodesmus acicularis A.Br Roll	-	-	+	-	-	+	+		-	-	-	-
Ankistrodesmus spiralis (Turner)	-	-	-	-	-	-		+	-	-	-	-
Ankistrodesmus falcatus (Corda) Ralfs	-	-	-	-	-	-	+	-	-	-	-	+
Botryococcus braunii Kuetz.	-	-	-	-	-	-	-	+	-	-	-	+
Chlorella vulgaris Beijerinck	-	-	-	-	-	-	+	-	-	-	-	+
Chlorococcum infusionum (Schrank) Menegh	-	-	-	-	-	-	+	+	-	-	-	+
Cladophora glomerata (L.) Kuetz.	-	-	-	-	-	-	-	-	-	-	-	+
Closterium acerosum (Schrank)Ehr.	-	-	-	-	-	-	+	-	-	-	-	+
Coelastrum reticulatum (Dang.) Senn	-	+	-	-	-	-	-	+	-	+	-	-
Cosmarium pyramidatum Berb	-	-	-	-	-	-	-	+	-	-	-	+
Crucigenia fenestrata(Schmidle)	-	-	-	-	-	-	-	-	-	-	-	+
Dictyosphaerium pulchellum Wood	-	+	-	-	-	-		+	-	-	-	-
Eudorina charkowiensis (Kors.) Pascher	-	-	-	-	-	+	+	-	-	-	-	+
Eudorina indica Iyengar	-	-	-	-	-	+	+	-	-	-	-	-
Spirogyra sp.	-	-	-	-	-	-	+	-	-	-	-	-
Spirogyra stictica (Engl.Bot) Wille	-	-	-	-	-	-	+	+	-	-	-	-
Mougeotia robusta (de Bary) Wittrock	-	-	-	-	-	-	-	+	-	-	-	-
Oedogonium crassum(Hass.)Wittrock	-	-	-	-	-	-	-	-	-	-	-	+
Oocystis borgei Snow	-	-	-	-	-	-	-	-	-	-	-	+
Pandorina morum(Bory) Mull.	-	-	-	-	-	-	+	-	-	-	-	+
Pediastrum duplex Meyen	-	-	-	-	-	-	+	-	-	-	-	-
Pediastrum simplex Meyen	-	-	-	-	-	-	+	+	-	-	-	-

Pediastrum simplex var. *duodenarium* (Bailey) Rabenhorst	-	-	-	-	-	-	+	-	-	-	-	+
Pediastrum obtusum Lucks	-	-	-	-	+	-	+	+	-	-	-	-
Scenedesmus acuminatus (Lagerheim) Chodat	-	+	-	-	-	-	-	-	-	-	-	+
Scenedesmus bijuga (Turp.) Lagerheim	-	-	-	-	+	-		+	-	+	-	+
Scenedesmus bijugatus (Turp.) Kuetz.	-	-	-	-	-	-	+	-	-	+	-	-
Scenedesmus dimorphus (Turp.) Kuetz.	-	+	-	-	+	-	-	-	-	-	-	+
Scenedesmus arcuatus var.*platydisca* G.M.Smith.	-	-	-	-	-	-	+		-	-	-	+
Scenedesmus quadricauda (Turp) Breb.	-	-	-	-	-	-	+	+	-	+	-	-
Scenedesmus quadricauda var.*longispina* (Chodat) Smith	-	-	-	-	-	-	+	-	-	-	-	-
Tetraedron trigonum (Naeg.) Hansg.	-	-	-	-	-	-	-	+	-	-	-	+
Zygnema sp. Agardh	-	-	-	-	-	-	+	+	-	-	-	+
Cyanophyceae												
Anabaena variabilis var. ellipsospora Kuetz.	-	-	-	-	+	-	-	+	-	-	-	+
Anabaena ambigua Rao, C. B.	-	-	-	-	+	-		-	-	-	-	-
Aphanocapsa biformis A.Br.	-	-	-	+	-	-	+	+	-	-	-	+
Chroococcus pallidus Naegeli	-	-	-	-	+	-	-	+	-	+	-	-
Chroococcus minutus (Kuetz.) Naegeli.	-	+	-	-	+	-	-	+	-	-	-	+
Chroococcus turgidus(Kuetz.) Naegeli	-	+	-	-	+	-	-	-	-	+	-	-
Gloeocapsa livida (Carm.) Kuetz.	-	+	-	+	+	+	+	+	+	+	+	+
Gloeocapsa punctate Naegeli	-	-	-	-	+	-	+	+	-	+	-	+
Gloeocapsa aeruginosa (Gram.)	+	-	-	+	+	+	-	+	+	-	-	-
Lyngbya major Meneghini	-	-	-	-	-	-	-	+	-	-	-	+
Merismopaedia elegans A.Braun .	-	-	-	-	+	-	-	-	-	+	-	+
Merismopaedia glauca (Ehr.) Naegeli	-	-	-	-	+	-	-	+	-	+	-	-
Microcystis flos-aquae (Wiltr.) Kirchner	-	-	-	-	+	-	-	-	-	-	-	+
Microcystis aeruginosa Kuetz.	-	-	-	-	+	-	+	-	-	-	-	-
Nostoc commune Vaucher ex Born. et flah	-	-	-	-	+	-	-	+	-	-	-	+
Nostoc muscorum C.A. Agardh	-	-	-	-	-	-	+	+	-	-	-	-
Oscillatoria articulate Gardner	-	-	-	-	+	-	+	+	-	-	+	+
Oscillatoria Formosa Bory ex Gomont	-	+	-	-	+	-	+	+	-	+	-	+
Oscillatoria limosa (Roth) Agardh	-	-	-	-	+	-	-	-	-	+	-	+
Oscillatoria amoena (Kuetz.) Gomont	-	+	-	-	-	-	-	+	-	+	-	+
Oscillatoria tenuis Ag. ex Gomont	-	-	-	-	+	-	-	+	-	-	-	-
Phormidium uncinatum (C. Agardh) ex Gomont	-	-	-	-	-	-	-	-	-	-	-	+
Sctyonema bohneri Schmidle	-	-	-	-	-	-	-	+	-	-	-	-
Euglenophyceae												
Euglena acus Ehr.	-	+	-	-	-	-	-	-	-	-	-	+
Phacus longicauda (Ehr) Dujardin	-	+	-	-	+	-	-	+	-	+	-	+
Phacus caudatus Hubner	-	+	-	-	-	-	+	+	-	-	-	+
Phacus curvicauda Swir.	-	+	-	-	+	-	-	+	-	-	-	+
Trachlelomonas similis Stokes	-	-	-	-	-	-	-	-	-	-	-	+

.+ = Present ; - = Absent: TW= Tube Well; DW = Dug Well; RS= Railway Supply ; MS= Municipal Supply ; RG= River Ganga

Figure 1: Total Phytoplankton Species Found in Drinking Water of Katihar District



Class	Genera	Species	% of Species
Bacillariophyceae	17	49	44
Chlorophyceae	21	35	31
Cyanophyceae	11	23	21
Euglenophyceae	03	05	04
Total	52	112	100

Algal species identified in different drinking water sources at different sites of Katihar ddistrict are depicted in Table 1. Altogether 112 phytoplankton species belonging to 52 genera were identified during the study period (Fig.-1). Phytoplankton population mainly consisted of four major Divisions namely Bacillariophyceae (17 genera and 49 species), Chlorophyceae (21 genera and 35 species), Cyanophyceae (11 genera and 23 species) and Euglenophyceae (03 genera and 05 species).

4.2 Distribution

Table 2: Distribution of Phytoplankton Species in Different Drinking Water Sources at Different Sites of Katihar District.

Site	Drinking Water	Bacillariophyceae		Chlorophyceae		Cyanophyceae		Euglenophyceae		Overall Number	
		Genera	Species	Genera	Species	Genera	Species	Genera	Species	Genera	Species
Site-I	Tube well	0	0	0	0	1	1	0	0	1	1
	Dug well	7	15	4	5	3	5	2	4	16	33
	Railway supply	0	0	1	1	1	1	0	0	2	2
Site-II	Tube well	0	0	0	0	2	3	0	0	2	3
	Dug well	8	20	3	4	7	17	1	2	19	43
	Railway supply	1	1	2	3	1	2	0	0	4	6
	Municipal supply	8	17	11	21	5	7	1	1	25	46
	River Ganga	15	32	12	14	9	16	1	3	37	65
Site-III	Tube well	0	0	0	0	1	2	0	0	1	2
	Dug well	5	13	2	4	4	9	1	1	12	23
Site-IV	Tube well	0	0	0	0	2	2	0	0	2	2
	River Ganga	11	28	17	20	10	14	3	5	41	67

Table 2 depicts the distribution of phytoplankton in different drinking water sources at different sites of Katihar District. Out of a total of 52 genera and 112 species of phytoplankton, Site - I exhibited 01 genus and 01 species in tube wells, 16 genera and 33 species in dug wells and 02 genera and 02 species in railway supply water, Site-II 02 genera and 03 species in tube wells, 19 genera and 43 species in dug wells, 04 genera and 06 species in railway supply, 25 genera and 46 species in municipal supply water and 37 genera and 65 species in river Ganga water, Site-III 01 genus and 02 species in tube wells and 12 genera and 23 species in dug wells and Site-IV 02 genera and 02 species in tube wells and 41 genera and 67 species in river Ganga. Maximum

phytoplankton species (41 genera and 67 species) were recorded in river Ganga at Site-IV and minimum species (01 genus and 01 species) were recorded in tube wells water at Site-I.

4.3 Abundance

Table 3: Average Monthly and Seasonal Fluctuations in Number (Organism/Litre) of Different Groups of Phytoplankton in Underground Water (Tube Wells) at Different Sites of Katihar Districts.

Sea	Mon	Site-I					Site-II					Site-III					Site-IV				
		BAC	CHL	CYA	EUG	TPD	BAC	CHL	CYA	EUG	TPD	BAC	CHL	CYA	EUG	TPD	BAC	CHL	CYA	EUG	TPD
S	Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr	0	0	0	0	0	0	0	2	0	2	0	0	4	0	4	0	0	4	0	4
	May	0	0	2	0	2	0	0	3	0	3	0	0	1	0	1	0	0	2	0	2
	Jun	0	0	6	0	6	0	0	5	0	5	0	0	5	0	5	0	0	5	0	5
	Avg	0	0	2	0	2	0	0	2.5	0	2.5	0	0	2.5	0	2.5	0	0	2.75	0	2.75
R	Jul	0	0	3	0	3	0	0	2	0	2	0	0	1	0	1	0	0	2	0	2
	Aug	0	0	0	0	0	0	0	2	0	2	0	0	3	0	3	0	0	0	0	0
	Sep	0	0	2	0	2	0	0	3	0	3	0	0	0	0	0	0	0	2	0	2
	Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	Avg	0	0	1.25	0	1.25	0	0	1.75	0	1.75	0	0	1	0	1	0	0	1.25	0	1.25
W	Nov	0	0	2	0	2	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1
	Dec	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	1	0	1
	Jan	0	0	3	0	3	0	0	2	0	2	0	0	4	0	4	0	0	2	0	2
	Feb	0	0	1	0	1	0	0	3	0	3	0	0	0	0	0	0	0	4	0	4
	Avg	0	0	1.5	0	1.5	0	0	2	0	2	0	0	1.25	0	1.25	0	0	2	0	2

Sea = Season; Mon = Month; S = Summer; R = Rainy; W = Winter; AVG = Average; TPD = Total Phytoplankton Density; BAC = Bacillariophyceae; CHL = Chlorophyceae; CYA = Cyanophyceae; EUG = Euglenophyceae.

Table 4: Average Monthly and Seasonal Fluctuations in Number (Organism / Litre) of Different Groups of Phytoplankton in Sub-Surface Water (Dug Wells) at Different Sites of Katihar District.

Sea	Mon	Site-I					Site-II					Site-III				
		BAC	CHL	CYA	EUG	TPD	BAC	CHL	CYA	EUG	TPD	BAC	CHL	CYA	EUG	TPD
S	Mar	62	59	45	2	168	86	87	66	0	239	78	51	72	0	201
	Apr	85	45	52	0	182	75	82	88	0	245	93	66	112	0	271
	May	184	74	84	3	345	114	67	97	3	281	125	75	127	2	329
	Jun	156	97	88	0	341	227	75	120	2	424	185	125	145	2	457
	Avg	121.8	68.75	67.25	1.25	259	125.5	77.75	92.75	1.25	297.3	120.3	79.25	114	1	314.5
R	Jul	88	42	42	0	172	92	72	52	0	216	85	155	22	0	262
	Aug	90	39	35	1	165	100	88	45	0	233	123	78	54	0	255
	Sep	112	87	59	0	258	85	54	42	0	181	102	65	43	0	210
	Oct	124	102	62	0	288	76	86	76	0	238	126	54	68	0	248
	Avg	103.5	67.5	49.5	0.25	220.8	88.25	75	53.75	0	217	109	88	46.75	0	243.8
W	Nov	88	56	31	7	182	65	56	55	6	182	113	63	84	3	263
	Dec	152	95	74	9	330	105	98	64	11	278	126	74	121	7	328
	Jan	122	68	64	8	262	121	101	46	8	276	106	101	88	4	299
	Feb	102	75	61	10	248	80	103	85	4	272	111	107	81	5	304
	Avg	116	73.5	57.5	8.5	255.5	92.75	89.5	62.5	7.25	252	114	86.25	93.5	4.75	298.5

Sea = Season; Mon = Month; S = Summer; R = Rainy; W = Winter; AVG = Average; TPD = Total Phytoplankton Density; BAC = Bacillariophyceae; CHL = Chlorophyceae; CYA = Cyanophyceae; EUG = Euglenophyceae.

Table-5: Average Monthly and Seasonal Fluctuations in Number (Organism /Litre) of Different Groups of Phytoplankton in Surface Water (Railway and Municipal Supply) at Different Sites of Katihar District

Sea	Mon	RAILWAY SUPPLY										MUNICIPAL SUPPLY				
		Site-I					Site-II					Site-I				
		BAC	CHL	CYA	EUG	TPD	BAC	CHL	CYA	EUG	TPD	BAC	CHL	CYA	EUG	TPD
S	Mar	0	0	0	0	0	0	1	0	0	1	75	24	14	3	116
	Apr	0	0	0	0	0	0	1	1	0	2	61	73	29	0	163
	May	0	2	2	0	4	1	0	2	0	3	106	88	31	9	234
	Jun	0	4	3	0	7	2	3	4	0	9	125	132	61	11	329
	Avg	0	1.5	1.25	0	2.75	0.75	1.25	1.75	0	3.75	91.75	79.25	33.75	5.75	210.5
R	Jul	0	1	0	0	1	0	3	1	0	4	55	78	13	0	146
	Aug	0	0	0	1	1	0	2	0	0	2	36	26	8	0	70
	Sep	0	0	0	0	0	0	0	0	0	0	42	45	19	0	106
	Oct	0	0	0	0	0	2	1	0	0	3	38	38	37	0	113
	Avg	0	0.25	0	0.25	0.5	0.5	1.5	0.25	0	2.25	42.75	46.75	19.25	0	108.75
W	Nov	0	0	0	0	0	0	3	0	0	3	78	61	31	12	182
	Dec	0	1	1	0	2	0	3	1	0	4	116	100	24	17	257
	Jan	0	4	0	0	4	0	3	2	0	5	105	128	30	13	276
	Feb	0	2	1	0	3	2	2	2	0	6	59	68	34	8	169
	Avg	0	1.75	0.5	0	2.25	0.5	2.75	1.25	0	4.5	89.5	89.25	29.75	12.5	221

Sea = Season; Mon = Month; S = Summer; R = Rainy; W = Winter; AVG = Average; TPD = Total Phytoplankton Density; BAC = Bacillariophyceae; CHL = Chlorophyceae; CYA = Cyanophyceae; EUG = Euglenophyceae

Table-6: Average Monthly and Seasonal Fluctuations in Number (Organism /Litre) of Different Groups of Phytoplankton in Surface Water (River Ganga) at Different Sites of Katihar District.

Sea	Mon	Site-II					Site-IV				
		BAC	CHL	CYA	EUG	TPD	BAC	CHL	CYA	EUG	TPD
S	Mar	202	264	75	15	556	216	324	236	21	797
	Apr	224	206	106	13	549	315	305	240	29	889
	May	356	275	214	21	866	329	314	251	42	936
	Jun	484	305	278	26	1093	504	395	305	55	1259
	Avg	316.5	262.5	168.25	18.75	766	341	334.5	258	36.75	970.25
R	Jul	85	114	123	5	327	142	87	145	6	380
	Aug	38	124	84	0	246	129	102	65	0	296
	Sep	46	84	32	0	162	114	114	75	0	303
	Oct	32	61	28	3	124	105	154	91	0	350
	Avg	50.25	95.75	88	2	214.75	122.5	114.25	94	0	332.25
W	Nov	185	175	124	0	484	155	298	132	0	585
	Dec	274	205	189	2	670	378	286	159	12	835
	Jan	265	226	105	5	601	275	304	203	14	796
	Feb	205	251	124	3	583	317	345	257	11	930
	Avg	232.25	214.25	135.5	2.5	584.5	281.25	308.25	187.75	9.25	786.5

Sea = Season; Mon = Month; S = Summer; R = Rainy; W = Winter; AVG = Average; TPD = Total Phytoplankton Density; BAC = Bacillariophyceae; CHL = Chlorophyceae; CYA = Cyanophyceae; EUG = Euglenophyceae

Average monthly and seasonal fluctuations in abundance / number (Organism/Litre) of different groups of phytoplankton in underground water (Tube Wells) at different sites of Katihar District are depicted in Table-3. The abundance of Bacillariophyceae group ranged from 00 - 504 OL^{-1}, Chlorophyceae group 00 - 395 OL^{-1}, Cyanophyceae group 00 - 305 OL^{-1} and Euglenophyceae group 00 - 55 OL^{-1}. Table 3 to 6 indicate the comparative studies of phytoplankton of different drinking water sources. The total phytoplankton density ranged from 00 to 07 OL^{-1} in tube wells, 165 to 457 OL^{-1} in dug wells, 00 to 09 OL^{-1} in railway supply, 70 to 329 OL^{-1} in municipal supply and 124 to 1259 OL^{-1} in river Ganga water. Total phytoplankton density was recorded maximum 1259 OL^{-1} in river Ganga water at Site-IV and minimum 00 OL^{-1} in tube wells and railway supply water at all sites except tube

well water at Site-II. Seasonal variation was profoundly observed on different drinking water sources with different groups of phytoplankton. In tube well water Cyanophyceae was dominant with highest population density during summer followed by winter and rainy season. In dug well water, Bacillariophyceae was dominant with the highest population density during summer followed by winter and rainy season. In railway and municipal supply water Chlorophyceae was dominant with the highest density value during summer followed by winter and rainy season. In river Ganga water, Bacillariophyceae was dominant with peak value during summer followed by winter and rainy season.

V. DISCUSSION

The phytoplankton assemblage of different drinking water sources at different sites of Katihar district was diverse, heterogeneous and abundant. This indicates the presence of varied amount of nutrients in different drinking water sources 0f Katihar District. The order of abundance and assemblage of the phytoplankton in drinking water of Katihar district, Bacillariophyceae > Chlorophyceae > Cyanophyceae > Euglenophyceae was similar to the observation of many biologists [27,28,29]. A comparative study states that the density and the variety of species of phytoplankton were maximum in the river Ganga water. It may be due to anthropogenic activities on the banks of river by the adjoining villages. It was also observed during the study that the local villagers accessed river Ganga to wash cattle and cloths. Higher phytoplankton density was also linked to higher inputs of nutrients in the river Ganga coming from rocks and sediments and exposure of large area of water surface to light leading to algal growth. Kumar have also found higher value to phytoplankton in river Ganga water [30]. On the other hand, Bacillariophyceae and Euglenophyceae taxa were completely absent in tube wells, whether low density of Chlorophyceae and Cyanophyceae taxa present in tube wells was attributed to factors such as higher value of pH and unavailability of direct sunlight and oxygen. Kumar have recorded the similar findings in different drinking water sources in Bhagalpur [31]. Higher density of phytoplankton present in dug wells and municipal supply water indicates higher level of pollution. In railway supply water, phytoplankton was nearly absent or present in very low density. It is attributed that the algal growth is controlled by chlorination in railway supply water. The filtration of water more or less completely eliminates algae from water.

Higher phytoplankton abundance during summer seasons has also been recorded by several workers [31, 32]. Favourable water temperature and pH, low turbidity, high transparency, greater solar illumination and richer nutrient level during summer helped the phytoplankton community to increase. Likewise, high turbidity, low transparency, lesser penetration of light, fast water current and overcast sky were responsible for lowering down the phytoplankton during the rainy season. These observations are in conformity with the findings of Mahor and Singh and Jayabhaye [32, 33].

In the course of present investigation, the number of Bacillariophyceae was observed higher during summer season and lower during rainy season in all water sources. This finding is in concurrence with Kumar [30] but contrary to Kumar and Choudhary [12] and Jayabhaye [33]. Some species of diatoms like *Cocconeis placentula, Navicula radiosa* var. *Minutissima* and *Synedra ulna var. amphirhynchus* recorded during the study are known for unpleasant taste and odour producing algae. *Cyclotella meneghiana, Melosira granulata, Synedra ulna, Cocconeis placentula, Cymbella tumida and Gomphonema sphaerophoru,* identified during the study are filter clogging algae. Some species of *Navicula* are known for corrosion problems. Some species of *Cyclotella, Nitzschia* and *Scenedesmus* present in drinking water are able to pass through the pores of sand filters. Species of *Synedra* can pass through the rapid sand filters while species of *Navicula* through slow sand filters. Species of *Cymbella* and *Gomphonema* may form slime in the pipes of filters, on the walls of the reservoirs and wells. Species of *Nitzschia, Fragilaria* and *Gomphonema* indicate moderate pollution of water. They are also responsible for coloration of water. Presence of *Pinularia* and *Fragilaria* species suggests that the water body is rich in organic pollution.

Members of Chlorophyceae were observed throughout the study period mostly in all water sources except tube wells but their maximum density was observed during winter season and minimum density during rainy season. Low temperature, less nitrate, bright sunshine and higher transparency were favourable for the growth of green algae in water body. Findings of the present study resemble with the works of Kumar and Choudhary [12] and Jayabhaye [33]. But Mahor and Singh had recorded maximum Chlorophycean members during summer [32]. *Mougeotia robusta* present in Ganga water is well known for imparting unpleasant taste and odour to water. *Scenedesmus bijuga* present in dug well and Ganga water is filter penetrating algae. *Ankistrodesmus falcatus, Pediastrum duplex, Scenedesmus acuminatus, Scenedesmus bijuga, Scenedesmus dimorphus, Scenedesmus quadricauda* may clog filters and create operational difficulties. Species of *Chlorella, Coelastrum, Eudorina, Mougeotia, Oocystis, Pandorina, Pediastrum, Scenedesmus and Zygnema* present in water during the study may impart green colour to water. *Chlorococcum infusionum* recorded from municipal supply and Ganga water is the indicator of high organic wastes whereas the presence of *Ankistrodesmus falcatus, Scenedesmus acuminatus* and *Scenedesmus quadricauda* is the characteristics of medium level of organic contents.

During summer season, Cyanophycean members were found in the flourishing condition in dug wells and river Ganga water. Among all blue-green algae, *Gloeocapsa livida* was one of the most prominent species which was found in large numbers in the all water sources throughout the year. Bright sunshine is more significant than temperature in the production of blue-green algae. These observations were in conformity with Jayabhaye [33]. *Microcystis aeruginosa* present in municipal and dug well water is a filter penetrating and the most serious clogging algae. *Oscillatoria amoena, Oscillatoria articulata, Oscillatoria limosa* and *Chroococcus minutes* are filter clogging and *Merismopaediaglauca* is filter penetrating algae. *Oscillatoria tenuis* may produce unpleasant taste and odour in water. Species of *Gloeocapsa* are responsible for corrosion problem in water. Some species of *Microcystis* and *Lyngbya* are harmful for water consumers [31]. Their linkage with gastrointestinal disorders, tumours, hemorrhaging and even death and cyanobacteria has been reported by many workers. Presence of the known toxin producing *Microcystis aeruginosa* in the drinking water indicates a potential hazard for human health [34].

Members of Euglenophyceae were observed maximum during winter seasons in dug wells and municipal supply water. In river Ganga water, maximum population of Euglenophyceae was recorded during summer and minimum during rainy season. This is in accordance with Kumar [30] but contrary to Jayabhaye who observed the maximum Euglenophycean population during monsoon period when the water shows sufficient amount of dissolved oxygen and good amount of nutrients [33]. Absence of Euglenoids in tube wells and railway supply water proves that high nutrients and organic matters are essential for the growth of Euglenoid algae.

VI. CONCLUSION

Above findings reveal that different drinking water sources viz. Tube well, dug well, river Ganga, municipal supply and railway supply are invariably contaminated with different phytoplankton which are responsible for deteriorating the quality of different drinking water sources. Thus people inhabiting in and around the above mentioned drinking water sources may be affected by different water-borne diseases due to regular consumption of such water. Presence of phytoplankton in municipal supply drinking water is a matter of serious concern. It indicates that municipality of Katihar district supplies water without proper treatment. It needs to be treated properly. Railway supply water is safer for drinking purposes but its regular monitoring is essential for maintaining the quality. However, it is restricted only to railway passengers and not available for majority of the people. Tube well water is usually free from phytoplankton contaminant but may be chemically or bacteriologically contaminated. Hence it should also be tested thoroughly for other contamination before consumption. Higher density of phytoplankton in the river Ganga water followed by dug well water indicates that these water should be filtered before consumption. Direct consumption of river Ganga water should be avoided because it is not only contaminated with phytoplankton but also largely contaminated with bacteria and hazardous chemicals *etc.* An effective policy, attention and awareness are needed for consumption of pure drinking water especially for rural areas and low income group people who cannot afford costly filters for obtaining drinking water.

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