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Bacteriological Contamination in Different Drinking Water Sources of Katihar District and Its Health Impacts

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Abstract: ***Bacteria in our drinking water are one of the main sources of waterborne diseases all over the world. Our study was aimed to investigate the extent of bacterial contamination in different drinking water sources (Tubewell, Dugwell, Municipal supply, Railway supply and River Ganga. The potable quality of drinking water was assessed from some of the villages of four blocks (Katihar, Manihari, Amdabad and Barari block) of Katihar district. The experiment was conducted during March 2013 to Feb 2015. Total bacterial density was recorded higher in river Ganga water ($0.89\times10^7L^{-1}$ to $10.10\times10^7L^{-1}$) followed by dugwell ($0.56\times10^7L^{-1}$ to $2.62\times10^7L^{-1}$), municipal supply($0.18\times10^7L^{-1}$ to $1.21\times10^7L^{-1)}$, tubewell ($0.15\times10^7L^{-1}$to $1.96\times10^7L^{-1}$)and railway supply water($0.04\times10^7L^{-1}$to $1.21\times10^7L^{-1}$).Using MPN test the highest coliform count was (22 to 1612/100ml) inriver Ganga water and faecal coliform (00 to 395/100ml)in dugwell water. In the present investigation 13 bacterial species were identified. E. coli, S. faecalis, C. perfringens, P. vulgaris etc were found almost in every water sources. Our study concludes that drinking water of river Ganga and dugwell was greatly contaminated with coliform and faecal coliform and major improvements on priority basis is essential.***

Keywords: Tubewell, Dugwell, River Ganga, Railway supply, Bacterial contamination

1. Introduction

Bacteria occur naturally in the air, water and soil, but most outbreaks of bacteriological contamination in drinking water are due to water coming into direct contact with human and animal waste. The modern industrialized societies of the world, in spite of progressive water filtration methods, still suffer occasional outbreaks of water contamination from bacteria as heavy rainfall overwhelms sewage system and runoff from livestock feedlots enters our surface waters. The WHO guidelines place the greatest emphasis on the microbial quality of drinking water. According to the WHO, the lack of safe water supply and of adequate means of sanitation is accountable for as much as 80% of all sickness and diseases in developing countries [1]. Sewage containing human excreta is the most dangerous material that pollutes water. Good quality of water is odourless, colourless, tasteless and free from faecal contamination/biological contamination and contains chemical in harmless amounts[2]. Yet, millions of people worldwide are deprived of this water. They consume water that contains pathogenic or disease causing micro-organisms. Pathogenic micro-organisms may include bacteria, such as *Salmonella typhi*, *Vibrio cholerae*, *Shigella*, viruses such as Protovirus or Hepatitis and protozoa such as *Giardia lamblia* or *cryptosporidium parvum*. A wide range of pathogenic micro-organisms can be transmitted to human beings via water contaminated with faecal material. The usual mode of transmission is from person to person through what is termed as faecal oral rout. Human faecal matter is generally considered to riskier to human health as it is more likely to contain human enteric pathogen [3].

The first link between enteric disease and water contaminated with faecal waste was demonstrated by Snow and Budd in 1855 [4]. Recognition that water is a source of pathogenic micro-organisms was made in the late 19th Century. The common water borne bacterial diseases are gastro-intestinal illness, flue like symptoms like nausea, vomiting, diarrhoea, intestinal cramps, but occasionally death may occur due to overwhelming of immune systems from *E. coli0157:H7*. Shigelloisis from the *Shigelladysenteriae* bacterium is responsible for dysentery, bloody diarrhoea, fever cramps, vomiting, and sometimes death especially in children and chronic arthritis (Reiter's syndrome) in some cases. Cholera from *Vibrio cholerae* bacterium causes fever, severe headache, diarrhoea and sometimes death due to rapid dehydration. Typhoid from *Salmonella typhi* bacterium causes fever, headache, diarrhoea, rashes and sometimes intestinal haemorrhaging. *Pseudomonas* and *Klebsiella* may produce a variety of infections involving skin and mucous membranes of the eye, ear, nose and throat.

Nearly 1.5 billion people lack safe drinking water and at least 5 million deaths per year can be attributed to water borne diseases. According to WHO, approximately 250 thousand people die every day all over the world due to diseases (typhoid, cholera, dysentery etc.) caused by unhealthy water uses. Lack of hygiene, safe drinking water and proper sanitation are major causes of diarrhoea with highest number of morbidity and mortality in the developing countries [5]. Nearly 2 million people, mostly children, die because of infections related with inadequate water usage and hygiene [6]. Water is the chief medium for spread of these diseases and hence they are called water borne diseases [7]. It has been estimated that the consumption of untreated contaminated groundwater, faulty well construction and improper well location are the primary causes of these water borne outbreaks [8]. WHO (2006) in its "Guidelines for drinking water quality publication" highlighted at least 17 different and major genera of bacteria that may be found in tap water which are capable of seriously affecting human health [9].

Microbiological examination offers the most sensitive test for the detection of recent and potentially dangerous faecal pollution, thereby providing a hygienic assessment of water quality with high sensitivity and specificity. It is determined by looking for the presence of bacteria indicative of faecal (sewage) contamination, namely total coliform , *Escherichia coli*, *Streptococcus faecalis* and some thermo tolerant organisms such as *Clostridium perfringensn*[10, 11]. Total coliform occur naturally in soil and in the gut of humans and animals. Thus their presence in water may indicate faecal contamination. *E.coli* is present only in the gut of humans and animals. It is found in large number in the intestinal flora of humans [12]. Faecal coliforms should not be present in 100 ml of drinking water especially *E.coli*[9].Bacterial quality of water is determined by the qualitative and quantitative pattern of bacteria. The population density of bacteria depends upon temperature, salinity, the abundance of organic nutrients and on other physico-chemical parameters of drinking water [13,14], organic matter concentration and Sunlight [15, 16].

The abundance and diversity of bacteria may be used as an indicator for the suitability of water [17]. The use of bacteria as water quality indicators can be viewed in two ways. First, the presence of such bacteria can be taken as an indication of faecal contamination of the water and thus as a signal to determine why such contamination is present, how serious it is and what steps can be taken to eliminate it; second, their presence can be taken as an indication of the potential health risk that faecal contamination possesses - the higher the level of faecal contamination, the greater the risk of water borne diseases [18].The most widely used indicators are the coliform bacteria, which may be the total coliform that got narrowed down to the faecal streptococci [19,20,21]. Total coliform counts give a general indication of the sanitary condition of water supply. Most coliform bacteria do not cause disease. However, some rare strains of *E. coli*, particularly the strain 0157:H7 can cause serious illness. Recent outbreaks of disease caused by *E. coli* 0157:H7 have generated much public concern about this organism. *E. coli* 0157:H7 has been found in cattle, chickens, pigs and sheep. Most of the reported human cases have been due to eating undercooked hamburger. Bacteriological examination of drinking water quality is necessary to determine whether the quality of different drinking water sources are fit and safe for drinking, food and dairy industries or not. It is difficult to detect specific disease-causing organism in water that we drink every day. Therefore, detection of indicator organism of faecal origin in drinking water should get top priority. Smoke is an indicator of fire. Similarly, bacteria of faecal origin (Coliform/) are indicators of pollution from faecal sources, thereby warning that there may be more dangerous organism like *Vibrio cholerae, Salmonella, Hepatitis virus* etc. present in the water.

The present study was carried out to determine the bacteriological quality of drinking water. Major objective of the study was to investigate the extent of bacterial contamination among protected and unprotected water sources of Katihardistrictand to assess the quality of drinking water and the possible causes that influence their potability. The quantitative analysis of total bacterial density, total coliform and faecal coliform were used to judge the quality of water. Besides these, drinking water was also analysed for the presence of different pathogenic and non-pathogenic bacteria for the same purpose.

2. Study Area

Katihar is a small island-like district of north-eastern part of Bihar state. This district was created on 22nd October 1973. The district is situated on the confluence of three important rivers of India - the mighty Ganga (Southern boundary, 25 Kilometres from Katihartown), the magnificent Koshi (Western boundary, 30 Kilometres from Katihar town) and the beautiful Mahananda (flowing by the side of Katihar town). Graphically, this district lies between $25^0$42’ to $26^0$22’ North latitude and $87^0$10’ to $88^0$05’ East longitude. It is bounded in the north and west by Purnea district, in the south by Bhagalpur (Bihar) and Sahebganj (Jharkhand) districts, and in the east by South Dinajpur and Maldah Districts (West Bengal). Katihar is famous for being Divisional Railway headquarters and a Junction of seven Railway routes. The total geographical area of the district is 3057 sq.km. It is the 12th largest district of Bihar .Katihar district has three sub-divisions - Katihar, Barsoi and Manihari with sixteen community development blocks. In Katihar sub-division, the blocks are Katihar, Korha, Falka, Sameli, Barari, Kursela, Pranpur, Hasanganj, Dandkhora and Mansahi. In Barsoi sub-division, the blocks are Barsoi, Kadwa, Azamnagar and Balrampur. In Mahihari sub-division, there are two Community Development Blocks namely Manihari and Amdabad. There are 1548 villages, 238 pancayats and a District board in Katihardistrict.Four different blocks of Katihar district, namely Katihar, Manihari, Amdabad and Barari, were selected of drinking water resources. All the resources of drinking water like tube wells, dug wells, Railway supply, municipal supply and river Ganga, which are used by the people of this district, were studied.

SITE - I (Katihar Block) Water sources examined – Tubewell, Dugwell and Railway supply
SITE - II (Manihari Block) Water sources examined – Tubewell, Dugwell, Railway supply, Municipal supply and River Ganga
SITE - III (Amdabad Block) Water sources examined – Tubewell and Dugwell
SITE - IV (Barari Block) Water sources examined – Tubewell and River Ganga

3. Materials and Methods

3.1 Total Bacterial density (TBD) was estimated by standard plate count method recommended by APHA[22] and WHO [23]. Nutrient Agar (Hi media) medium was used for TBD test.

3.2 The standard test for the estimation of members of the total coliform (TC) and faecal coliform (FC) was carried out by the multiple tube dilution (MTD) test, *viz.* -presumptive test and confirmatory test. Lauryl Sulphate Tryptose broth (LST for presumptive test) and Brilliant Green Lactose Bile broth (BGLB for confirmatory test) were used for total coliform test. ECbroth, Sodium azide medium (Hi media) and Ethyl violet azide broth (Hi media) were used for faecal coliform test. Durham tube was inserted on both occasions to detect the gas formation in LST and BGLB broth**.**

3.3 Some other tests like IMViC test, Gram-stain test, Fermentation test, Nitrate-reductase test, oxidase test, H_2S test, citrate test and catalase test were done for identification of different bacteria by using specific media and indicators as recommended by APHA [22], WHO [23].

4. Results

Table1: Average Monthly and Seasonal Fluctuations in TBD ($x10^7 L^{-1}$) of Different Drinking Water Sources at Different Sites of Katihar Dist

Season	*Month*	*Underground Water*					*Sub-Surface Water*				*Surface Water*						
		Tubewell					*Dugwell*				*Rly. Supply*			*Mu. Supply.*	*River Ganga*		
		S-I	*S-II*	*S-III*	*S-IV*	*AVG*	*S-I*	*S-II*	*S-IV*	*AVG*	*S-I*	*S-II*	*AVG*	*S-I*	*S-II*	*S-IV*	*AVG*
S	*Mar*	0.66	0.42	0.63	0.26	0.4925	0.84	2.16	1.10	1.36667	0.09	0.12	0.105	0.34	3.26	1.58	2.42
	Apr.	0.64	0.38	0.50	0.34	0.465	1.28	1.66	0.8	1.24667	0.07	0.16	0.115	0.23	5.14	3.27	4.205
	May	0.76	0.46	0.44	0.32	0.495	0.89	0.82	0.68	0.79667	0.12	0.24	0.18	0.86	6.02	4.81	5.415
	Jun.	0.68	0.74	0.62	0.54	0.645	1.24	1.12	0.66	1.00667	0.14	0.18	0.16	0.44	5.27	3.96	4.615
	AVG	0.685	0.5	0.5475	0.365	0.52438	1.0625	1.44	0.81	1.10417	0.105	0.175	0.14	0.4675	4.9225	3.405	4.1638
R	*Jul*	0.86	0.66	1.96	0.28	0.94	1.78	2.33	1.89	2	0.43	0.54	0.485	0.87	6.16	3.47	4.815
	Aug	0.63	0.68	1.43	0.46	0.8	1.54	2.16	2.01	1.90333	0.50	0.66	0.58	1.19	8.41	7.38	7.895
	Sep.	0.89	0.84	1.88	0.56	1.0425	1.82	2.62	1.98	2.14	0.64	0.68	0.66	1.21	10.10	8.46	9.28
	Oct.	0.53	0.74	1.23	0.52	0.755	1.22	1.86	1.86	1.64667	0.24	0.36	0.3	0.84	7.59	6.31	6.95
	AVG	0.7275	0.73	1.625	0.455	0.88438	1.59	2.2425	1.935	1.9225	0.4525	0.56	0.50625	1.0275	8.065	6.405	7.235
W	*Nov*	0.68	0.62	0.34	0.48	0.53	1.24	1.67	1.64	1.51667	0.20	0.32	0.26	0.61	7.24	4.34	5.79
	Dec	0.42	0.35	0.30	0.24	0.328	0.84	1.68	1.07	1.19667	0.18	0.21	0.195	0.47	4.57	3.18	3.875
	Jan	0.36	0.22	0.28	0.15	0.2525	0.56	0.82	0.68	0.68667	0.04	0.06	0.05	0.18	1.09	0.89	0.99
	Feb	0.32	0.29	0.21	0.18	0.25	0.58	0.80	0.76	0.71333	0.05	0.06	0.055	0.26	1.98	1.02	1.5
	AVG	0.445	0.37	0.283	0.2625	0.34013	0.805	1.2425	1.0375	1.02833	0.12	0.1625	0.14	0.38	3.72	2.3575	3.0388

4.1 Quantitative analysis of bacteria

4.1.1Total Bacterial Density (TBD) or Colony Count (CC)

Table 1 showing Total Bacterial Density (TBD) or Colony Count (CC) varied from $0.32\times10^7L^{-1}$ to $0.89\times10^7L^{-1}$, $0.22\times10^7L^{-1}$ to $0.84\times10^7L^{-1}$, $0.21\times10^7L^{-1}$ to $1.9\times10^7L^{-1}$ and $0.15\times10^7L^{-1}$ to $0.56\times10^7L^{-1}$ in tube well water at Site-I to IV respectively. In dug well water it varied from $0.56\times10^7L^{-1}$ to $1.82\times10^7L^{-1}$ at Site-I, $0.80\times10^7L^{-1}$ to $2.62\times10^7L^{-1}$ at Site-II and $0.66\times10^7L^{-1}$ to $2.01\times10^7L^{-1}$ at Site-III. In railway supply water TBD varied from $0.04\times10^7L^{-1}$ to $0.64\times10^7L^{-1}$ and $0.06\times10^7L^{-1}$ to $0.68\times10^7L^{-1}$ at Site-I and Site-II respectively. It varied from $0.18\times10^7L^{-1}$ to $1.21\times10^7L^{-1}$ in municipal supply water at Site-II. In river Ganga water it varied from $1.09\times10^7L^{-1}$ to $10.10\times10^7L^{-1}$ at Site-II and $0.89\times10^7L^{-1}$ to $8.46\times10^7L^{-1}$ at Site-IV. Total bacterial density was recorded highest in river Ganga water followed by water of dug well, municipal supply, tube well and railway supply.

The higher value of TBD was found in September in all water sources at every site except at Site-III in tube well and dug well. Lower value was recorded in January in all water sources at every site except in tube well water at Site-I and Site-III and in dug well water at Site-II and Site-III. Among all different water sources, maximum value of TBD was observed at $10.10\times10^7L^{-1}$ in September in river Ganga water at Site-II and minimum value at $0.04\times10^7L^{-1}$ in January in railway supply water at Site-I

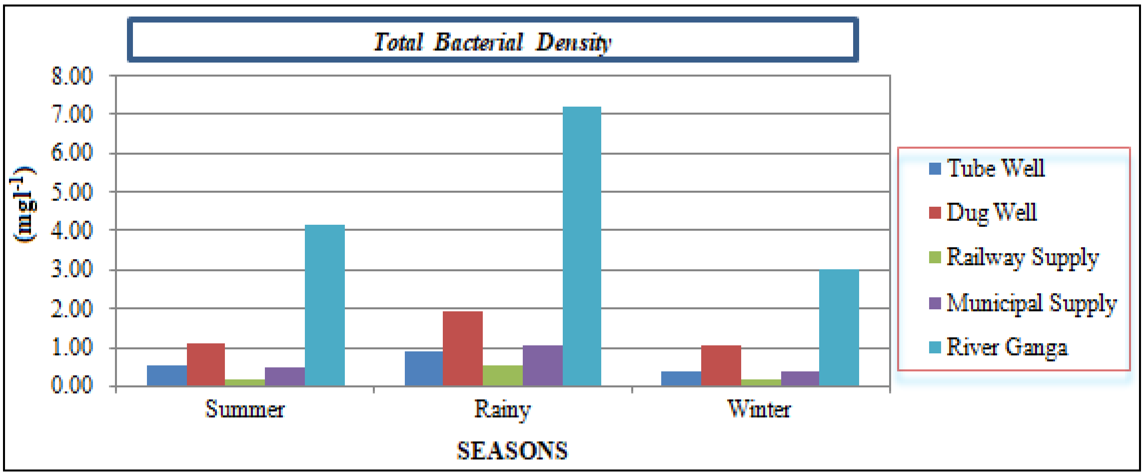

Figure 1: Average Seasonal Variations inTotal Bacterial Density (TBD) at Different Drinking Water Sources of Katihar Dist

Fig. 1 Showing Seasonal variation showed maximum value of TBD during rainy season in all water sources at every site and minimum value during winter season in all drinking water sources at every site, except dug well at Site-III, where the minimum value was recorded during summer season. Maximum value of TBD was observed in river Ganga followed by dugwell, municipal supply,dugewell and Railway supply water

Table 2: Average Monthly and Seasonal Fluctuations in MPN Coliform/ Total Coli (/100 ml) of Different Drinking Water Sources at Different Sites of Katihar Dist.

Season	*Month*	*Underground Water*					*Sub-Surface Water*				*Surface Water*						
		Tubewell					*Dugwell*				Railway Supply.			*Mun. Supp.*	*River Ganga*		
		S-I	*S-II*	*S-III*	*S-IV*	*AVG*	*S-I*	*S-II*	*S-IV*	*AVG*	*S-I*	*S-II*	*AVG*	*S-II*	*S-II*	*S-IV*	*AVG*
S	*Mar*	38	32	41	9	30	138	216	156.00	170	0	2	1	20	142	128	135
	Apr.	26	22	16.00	12	19	160	242	206	202.667	2	1	1.5	8	248	218	233
	May	37	14	19	11	20.25	206	272	234	237.333	4	6	5	18	184	108	146
	Jun.	41	18	10	10	19.75	164	278	221	221	2	5	3.5	12	62	32	47
	AVG	35.5	21.5	21.5	10.5	22.25	167	252	204.25	207.75	2	3.5	2.75	14.5	159	121.5	140.25
R	*Jul*	50	38	48	20	39	198	324	302	274.667	4	8	6	86	680	478	579
	Aug	56	52	36	43	46.75	396	620	460	492	7.00	6	6.50	50	855	740	797.5
	Sep.	90	78	46	51	66.25	752	950	826	842.667	10	10	10	90	1612.00	1572	1592.00
	Oct.	47	37	28	21	33.25	567	868	581	672	8	10	9	38	1360	1250	1305
	AVG	243	51.25	39.5	33.75	46.3125	478.25	690.5	542.25	570.333	7.25	8.5	7.875	66	1126.75	1010	1068.4
W	*Nov*	18	12	13	12	13.75	326	731	424	493.667	2.00	4	3.00	22	688	440	564
	Dec	12	9	9.00	10	10	150	461	204	271.667	0	0	0	12	216	112	164
	Jan	8	10	8	6	8	80	184	168	144	0	0	0	8	26	22	24
	Feb	14	16	6	8	11	89	143.00	142	124.667	0	0	0	7	38	28	33
	AVG	13	11.75	9	9	10.6875	161.25	379.75	234.5	258.5	0.50	1	0.75	12.25	242	150.5	196.25

4.1.2 Coliform/ Total Coliform (TC)

In the present study, **Table 2** shows that some sources of drinking water like dug well and river Ganga were found to be contaminated heavily with coliform. During the study, total coliform bacteria were recorded in the range of 08 - 90/100 ml at Site-I, 09 - 78/100 ml at Site-II, 06 - 48/100 ml at Site-III and 06 - 51/100 ml at Site-IV in tube well water in Katihar district. In dug well water TC ranged from 80 - 752/100 ml at Site-I, 143 - 950/100 ml at Site-II and 142 - 826/100 ml at Site -III. However, in railway supply water, TC ranged from 00 - 10/100 ml at I and II both Sites. In municipal supply water it ranged from 07 - 90/100 ml at Site-II and in river Ganga water, it ranged from 26 - 1612/100 ml at Site-II and 22 - 1572/100 ml at Site -IV. Higher value of TC was recorded in September in all water sources at every site. However, minimum value was observed in January in tube well water at Site-I and Site - IV, in dug well water at Site-I and in river Ganga water at all sites. In February, minimum value of TC was observed in tube well at Site-III, in dug well at Site-II & Site - III and in municipal supply water at Site-II. In railway supply water, lower value was observed in December, January, February and March at all sites. Among all different drinking water sources, higher value of TC was (1612/100 ml) observed in river Ganga water at Site-II and lower value (00/100 ml) in railway supply water at all sites.

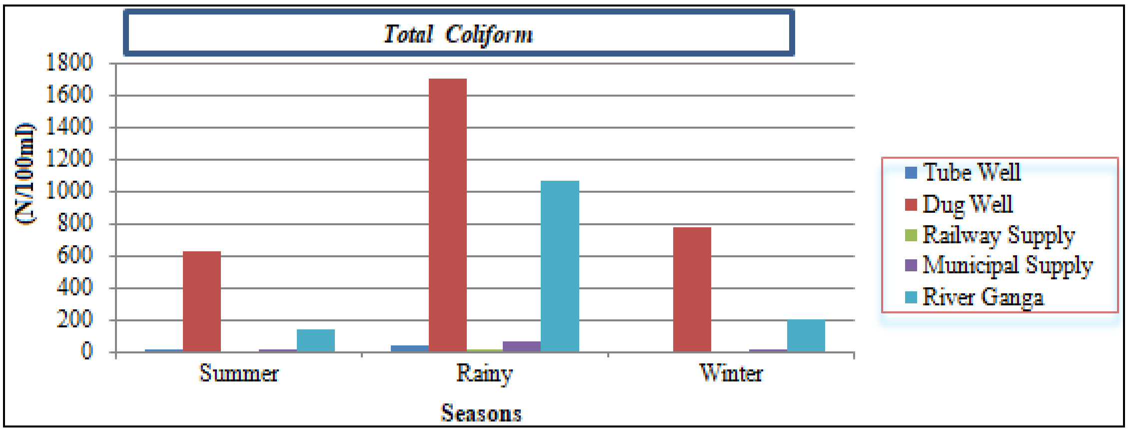

Figure 2: Average Seasonal Variations inTotal Coliform at Different Drinking Water Sources of Katihar Dist.

In **Fig 2,** Seasonal variation showed maximum value of TC during rainy season and minimum value during winter season in all water sources at every site. Higher value was observed in dugwell water followed by river Ganga, municipal supply, tubewell and railway supply water.

Table 3: Average Monthly and Seasonal Fluctuations in MPN Streptococci/Faecal coliform (/100 ml) of Different Drinking Water Sources at Different Sites of Katihar Dist

Seasons	*Mon.*	*Underground Water*					*Sub-Surface Water*				*Surface Water*						
		Tubewell					*Dugwell*				*Rly.Supply*			*Mun. Supply*	*River Ganga*		
		S-I	S-II	S-III	S-IV	AVG	S-I	S-II	S-III	AVG	S-I	S-II	AVG	S-I	S-II	S-III	AVG
S	*Mar*	2	2	0	0	1	0	10	11.00	7	0	0	0	0	36	27	31.5
	Apr.	12	8	5.00	2	6.75	18	32	28	26	0	0	0	6	64	36	50
	May	15	9	4	2	7.5	34	49	22	35	0	0	0	10	42	38	40
	Jun.	23	14	2	0	9.75	18	38	20	25.33	0	0	0	8	38	44	41
	AVG	13	8.25	2.75	1	6.25	17.5	32.25	20.25	23.33	0	0	0	6	45	36.25	40.625
R	*Jul*	20	12	8	4	11	28	49	54	43.66	0	2	1	32	162	116	139
	Aug	26	14	18	8	16.5	78	96	81	85	3.00	5	4.00	27	276	218	247
	Sep.	41	28	36	26	32.75	220	395	212	275.66	2	3	2.5	40	346.00	252	299.00
	Oct.	18	16	8	10	13	106	128	140	124.66	0	2	1	28	224	146	185
	AVG	26.25	17.5	17.5	12	18.3125	108	167	121.75	132.25	1.25	3	2.125	31.75	252	183	217.5
W	*Nov*	11	8	6	2	6.75	33	56	41	43.33	0.00	0	0.00	12	94	76	85
	Dec	4	3	5.00	3	3.75	18	36	28	27.33	0	0	0	0	46	34	40
	Jan	0	0	2	0	0.5	0	2	0	0.66	0	0	0	0	13	9	11
	Feb	0	0	2	0	0.5	2	8.00	4	4.66	0	0	0	0	20	11	15.5
	AVG	3.75	2.75	3.75	1.25	2.875	13.25	25.5	18.25	19	0.00	0	0.00	3	43.25	32.5	37.875

4.1.3 Streptococci or Faecal Coliform (FC)

Table 3showingfaecal coliform ranged from 00 - 41/100 ml at Site-I, 00 - 28/100 ml at Site-II, 00 - 36/100 ml at Site-III and 00 - 26/100 ml at Site-IV in tube well water ofKatihar district. However, in dug well water, it ranged from 00 - 220/100 ml at Site-I, 02 - 395/100 ml at Site-II and 00 - 212/100 ml at Site-III. In railway supply water, FS/FC ranged from 00 - 03/100 ml at Site-I and 00 - 05/100 ml at Site-II. In municipal supply water, it ranged from 00 - 40/100 ml at Site-II. In river Ganga water, it varied from 13 - 346/100 ml at Site-II and 09 - 252/100 ml at Site-IV. The faecal coliform was found to be higher in September month at all sites in tube well, dug well, municipal supply and river Ganga water .But in railway supply water higher value of FC was observed in August at all Sites. Lower value of FC was found in January and February in tube well water at Site-I, II and IV, in dug well and river Ganga water at all sites. However, lower value was also recorded in March in tube well at Site-III and IV, in dug well at Site-I and in municipal supply water. In railway supply water FS was found only in the months of August and September at Site-I and in August, September and October months at Site-II. Among different drinking water sources, maximum value of FC (395/100 ml) was recorded in dug well at Site-II and minimum value was recorded (00/100 ml) in tube well, dug well, railway supply water and municipal supply at all sites except dug well at Site-II.

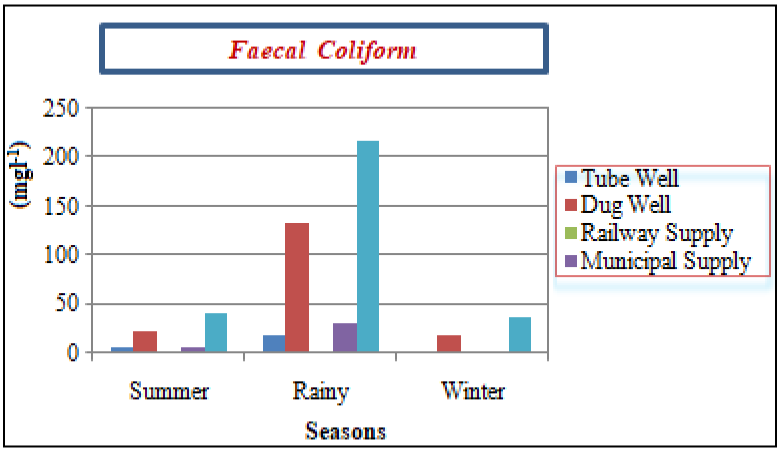

Figure 3: Average Seasonal Variations in Faecal Coliform at Different Drinking Water Sources of Katihar Dist

Seasonal variations in **Fig 3** showed maximum value of faecal coliform during rainy season in all sources at every site. The minimum value was observed during winter season in all water sources at every site except tube well water.

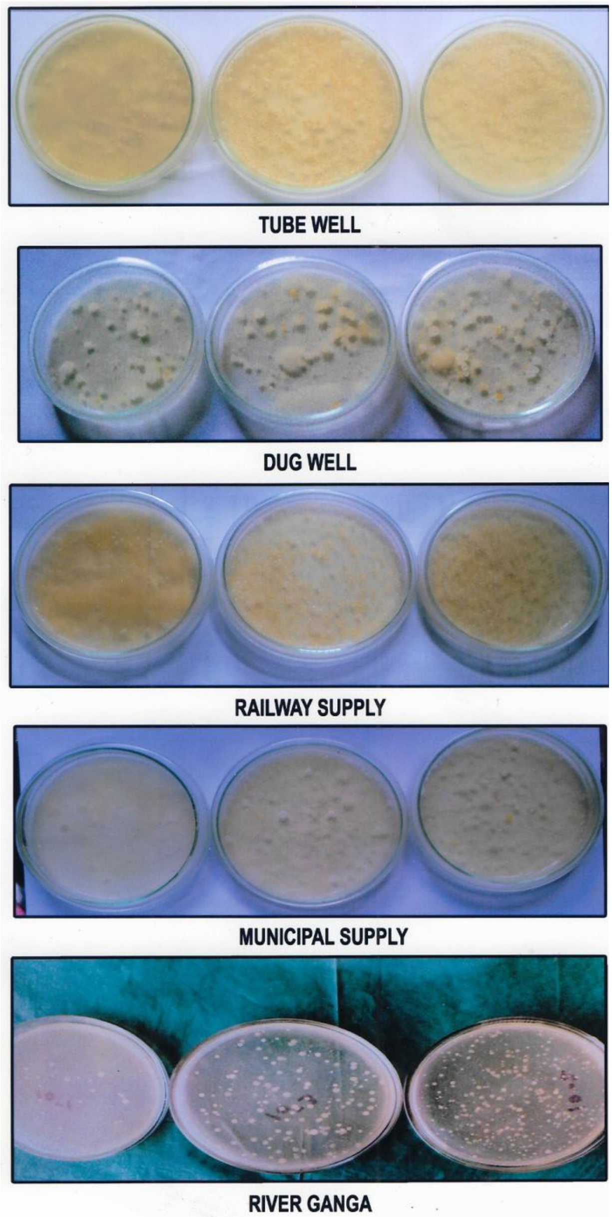

Figure 4: Bacterial Densities at Different Drinking Water sources in KatiharDistt.

4.2 Qualitative study of bacteria

Table 4: Bacterial Species Isolated from Different Drinking Water Sources at Different Sites of Katihar District

Bacteria	*Pathogenicity Known*	*site-I*			*site-II*					*site-III*		*site-IV*	
		T	*D*	*RS*	*T*	*D*	*RS*	*MS*	*R G*	*T*	*D*	*T*	*R G*
Aerobacteraerogenes	Non -pathogenic	-	+	+	-	+	+	+	+	+	+	+	+
Bacillus anthracis	Anthrax in man and cattle	-	-	-	-	+	-	-	-	-	-	-	+
Clostridium perfringens (=*C. welchii*)	Food poisoning and gas gangrene in man	-	-	-	-	-	-	-	+	-	+	-	+
Diplococcus sp.	-----	-	+	+	+	+	-	+	+	-	+	-	+
Escherichia Coli	Infantile & traveller's diarrhuea, wound infectons in man	+	+	-	+	+	-	-	+	-	+	+	+
Klebsiellapneumoniae	Pneumonia in man, guinea pigs and rabbits	+	-	-	+	+	-	-	+	+	-	+	+
Micrococcus sp.	------	-	-	-	+	+	-	+	+	+	+	-	+
Proteus vulgaris	Diarrhoea in man	+	+	-	-	+	+	+	+	-	-	+	+
Pseudomonas aeruginosa	Diarrhoea and abscess formation in man	+	+	-	+	+	-	+	+	+	+	-	+
Salmonella typhi	Typhoid fever in man	-	+	-	+	-	+	+	-	-	+	-	+
Salmonella paratyphi	Parayphoid fever in man	-	+	-	-	+	-	+	+	-	+	-	+
Staphylococcus aureus	Food poisoning , skin diseases in man	-	+	-	-	+	-	-	+	-	+	-	+
Streptococcus faecalis	Non -pathogenic	+	+	+	-	-	+	+	+	+	+	-	+

+ = Present ; - = Absent ; T = Tubewell; D = Dugwell; RS= Railway Supply; MS = Municipal Supply; RG = River Ganga

In the present investigation, altogether 13 bacterial species were identified at different sites of different drinking water sources of Katihar district (**Table-4**). Identified species of bacteria are *Aerobacteraerogenes, Bacillus anthracis, Clostridium perfringens, Diplococcus sp., Escherichia coli, Klebsiellapneumoniae, Micrococcus species, Proteus vulgaris, Pseudomonas aeruginosa, Salmonella typhi, Salmonella paratyphi, Streptococcus faecalis, and Staphylococcus aureus.* The qualitative variations were observed maximum during rainy season and minimum during winter season. Out of the total 13 species, 9 species were pathogenic.

5. Discussions

Bacteriological examination of water was thought necessary for determining the extent of bacterial contamination among different protected and unprotected drinking water sources of Katihar district and to assess the quality of drinking water. Bacteriological analysis of drinking water from different sources and at different sites of Katihar district reveal that the qualitative and quantitative value of bacteria are the highest in river Ganga followed by dug well water in comparison to tube well, railway supply and municipal supply water at all sites throughout the study period. In general the surface water sources are not acceptable for drinking purposes as these are often loaded with various biological constituents [24, 25, 26]. High bacterial pollution in river Ganga water has also been reported earlier by several workers [27, 28]. Similarly, Kumar (1992) has also reported high concentration of bacteria in river Ganga which may be attributed to the discharged sewage along with human and animal excreta, open defection practices, wallowing of cattle and other human activities [27]. Higher value in dug well may be as a result of seepage from septic tanks, contaminated surface wastes entering the dug well and improper installation of well casing or caps. Lower value in groundwater may be because of the overlying soil acting as a filter and in railway supply and municipal supply because of filtration and chlorination process.Sworobuk and Kumar have also suggested that groundwater was considered to be free from bacterial pollution and safe sources of drinking water because of its soil filtering process [27, 29].

Total bacterial density was higher in river Ganga water. Total counting of bacteria can be a more reliable index of water quality since the number of bacteria present depends upon the degree of contamination. Although they do not give any direct indication of presence of pathogens, increased bacterial abundance has been noted to be directly related with the outbreaks of water-borne diseases. Coliform and faecal coliform had higher presence in river Ganga and dug well water. Abdolmajidhas also observed high level of total coliform, *E. coli* in surface water (river) compared to ground water (well) [30].Various studies around the world assessing different water sources have revealed total coliform contamination rates ranging from 0% to 100% [31, 32]. Coliform bacteria are less likely to cause illness, but other disease causing organisms may be present in the water system. The absence of coliform bacteria in railway supply water leads to the assumption that the water supply is microbiologically safe to drink. Consuming water with coliform bacteria present may cause gastrointestinal illness, fever and other like symptoms. Therefore, drinking water standard requires no coliform bacteria.

Faecal coliform bacteria appear in great quantities in the intestines and faeces in people and animals. The presence of faecal coliform in drinking water samples often indicates recent faecal contamination. The presence of pathogens makes the water source potentially dangerous. The finding indicates that total coliform and faecal coliform are the maximum during monsoon followed by summer and winter. Higher bacterial contamination in rainy season may be due to runoff water having excreta of humans and animals. Kistemann*et al*. (2002) observed that in the case of rainfall, the microbial loads of running water may suddenly increase and reach reservoir bodies very quickly [21]. Similar findings were observed by Bilgrami and Kumar, 1998[28]. Identical to all findings of faecal streptococci were found maximum in monsoon followed by summer and winter. The study clearly reveals that there is significant presence of bacterial indicators of faecal pollution [33]. The situation of drinking water quality is not very serious but alarming. The present study supports that the quality of drinking water in Katihar is not up to the WHO (2004) standard[23].

6. Conclusions

Higher value of TBD, MPN coliform and faecal streptococci were observed in river Ganga water followed by dug wells, municipal supply, tube wells and railway supply water. The maximum value of TBD in river Ganga water indicates its high pollutional status due to high organic load. It may be due to addition of sewage containing suspended matter decayed vegetables and other wastes. Contamination of water with pathogenic organisms due to absence of fencing of water sources that could prevent the entrance of animals, people open area defecation, agricultural activities nearby by water sources and defect of disinfection of water sources. Although the concentration of FS was much lower than that of TC in most of the sources but their presence revealed faecal contamination of drinking water sources. The concentration of bacterial density was lowest is railway supply water which may be due to different water treatment processes like filtration, sedimentation, iron elimination and chlorination .Seasonal variations showed maximum value during rainy season (September month). Therefore during rainy season people should take greater attention for drinking water.

The occurrence of bacterial species like *Aerobacteraerogenes, Bacillus anthracis, E. Coli, Klebsiellapneumoniae* and *Pseudomonas aeruginosa* in drinking water sources and species *Clostridium perfringens (C.welchii*) recorded from river Ganga water sources is the indicator of contamination of human and animal faecal matter. Some bacterial species like *Proteus vulgaris, Pseudomonas aeruginosa* may become pathogenic when they get favourable hosts and conditions causing acute to severe diseases. The presence of bacteria in different sources of drinking water may be a risk of infection of various diseases (gastroenteritis, typhoid, dysentery, cholera, hepatitis, etc) to human beings. The water of tube well, railway supply and municipal supply are comparatively better as compared to other sources as far as microbial contamination is concerned. Therefore, this study strongly recommends maintenances, supervisions and regular bacteriological assessment of all drinking water sources should be planned and conducted. It also recommends chlorination or boiling of drinking water before use to avoid health risk in the inhabitants of the Katihar district.

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