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Research Article

Bacteriological Assessment of Groundwater Around the M.S.W Dumping Site at Ramchak-Bairiya, Patna, Bihar, India, Using the MPN Technique

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Abstract

Patna is the capital of Bihar. Residents of Patna used groundwater for their daily needs. Nowadays water pollution becomes a global concern and major cause of disease. Many factors involved in contaminating groundwater. One of the major factors for groundwater pollution is microbes, as water acts as a medium for their proliferation and growth. Open MSW dumping sites are source of microbial contamination, as leachate generated were laterally migrated into shallow aquifer. Present study investigates the microbiological quality of groundwater samples collected from 25 different houses situated near the municipal solid waste dumping site at Ramchak-Bairiya, Patna, Bihar, for three different seasons, i.e., pre-monsoon, monsoon and post-monsoon. Water samples were analysed by multiple tube fermentation tests to find out the total coliform count, and the results were shown in the MPN index. The result of MPN shows coliform contamination in almost all samples. Samples taken during monsoon season reveal maximum coliform concentration for all 25 locations. While for summer & winter seasons, coliform concentration became lower comparatively. Presence of coliform bacteria inside the groundwater sample clearly indicate percolation of contaminated leachate into shallow aquifers. Presence of coliform make these water unfit for drinking and domestic use. This study highlights that leachate from MSW dumping site at Ramchak-Bairiya percolates to the near aquifer. This leads to severe health risk and environmental issues.

Keywords

Groundwater, Coliform, Most Probable Number, MSW, Leachate, Bacteriological, Bihar

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1. Introduction

For the survival of human beings, water and oxygen are two most essential requirement. Our Earth covered with 70% water and 30% land, despite of availability of safe drinking water for human population is not adequate. India is the most populous country in the world and due to its increasing population and development, citizens of India experiences water shortages. Clean water is not available for about 2.6 billion people and about 3.4 million deaths occur due to waterborne diseases every year [1-3]. Ground water is the major source of drinking water in Bihar. Contaminated water contains infective and parasitic agents. Most of the microbes in water comes from human and animal excreta. Contamination of groundwater occurs due to rapid urbanisation and industrialisation, leading towards major environmental consequences [4]. Municipal solid waste (MSW) dumping sites became major threat to surrounding environment and nearby residents. In Bihar specially in Patna, open MSW dumping or landfill became a common process for municipal solid waste management. MSW dump sites were identified as serious threats to groundwater sources [5]. Nowadays a major environmental concern is the leachate generated from dump yard and its effect on groundwater [6]. Groundwater contamination by leachate near MSW dumping site had been studied [7]. Result of that study highlights the impact of leachate on groundwater and its contamination as observed with presence of Enterobacter. The presence of coliform and other pathogens in ground water mainly comes from leachate. Detection of coliform conducted by using MPN technique. In view of the health of residents around the Ramchak-Bairiya MSW dumping site at Patna, Bihar, the present study was dedicated to estimate the level of microbial contamination of groundwater collected from closed vicinity of dumping site. Findings of this study, highlights the importance of positive interaction to improve water quality, to assure access to safe drinking water, and to lowering the possibility of water diseases outbreak.

2. Materials and Methods

2.1. Study Area

Patna is located at 25° 6” N in latitude and 85° 1” E longitude and 174 m above mean sea level. Total area covered by Patna municipal corporation is 109 sq. km. This investigation was carried out at the Ramchak-Bairiya municipal solid waste dumping site at Patna, Bihar. A total of 25 groundwater samples were collected from different houses situated near dumping site (Ramchak-Bairiya) for 3 different seasons i.e., pre-monsoon, monsoon and post-monsoon. The map of study area as shown in Figure 1.

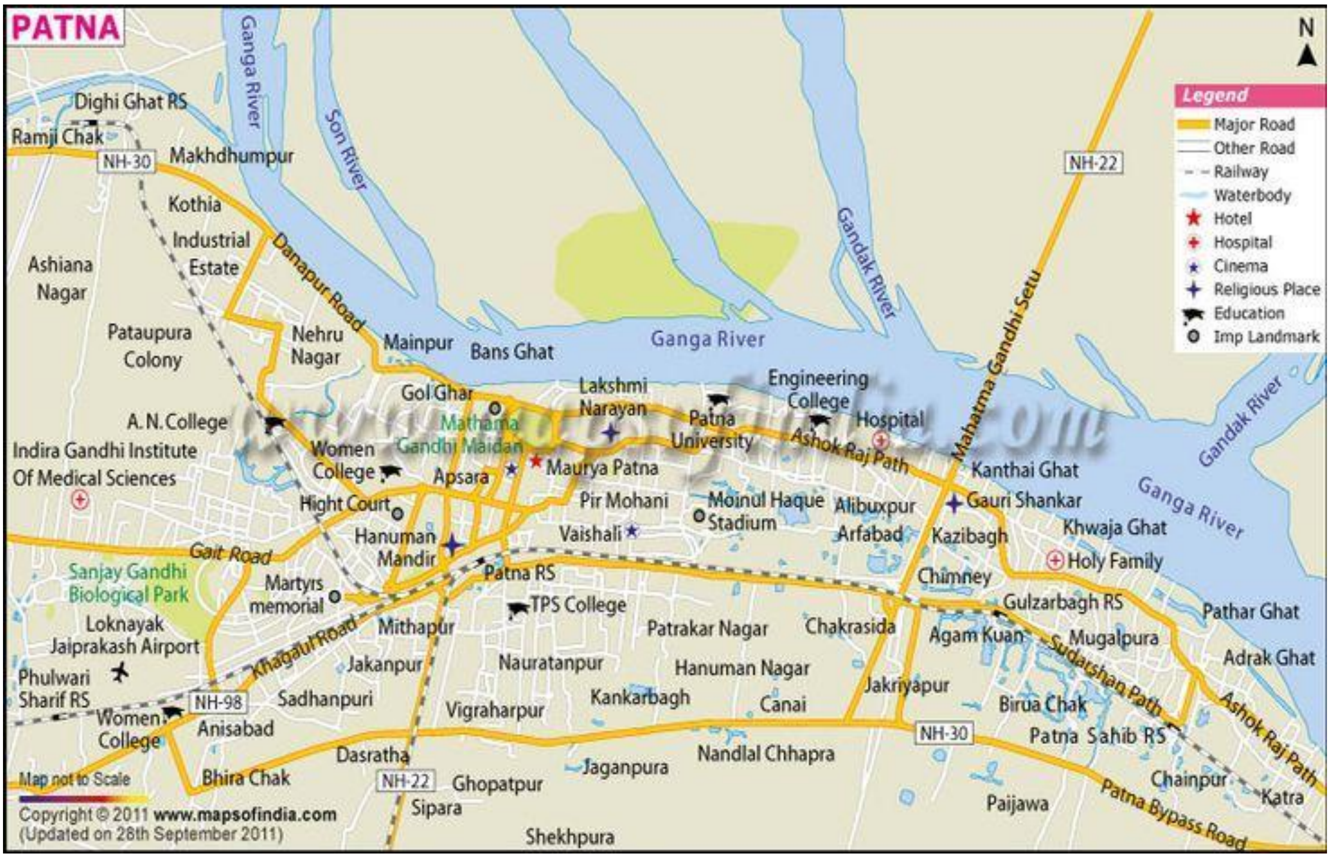

Figure 1. The map of Patna Municipal area.

2.2. Sample Collection

Groundwater samples were collected from 25 locations around dumping site of Ramchak-Bairiya. Clean and sterilised 100 ml sample collection containers were used for collection of water sample. After collection, containers were sealed with parafilm and transported to Department of Biotechnology, A. N. College, Patna laboratory inside an icebox.

2.3. Bacteriological Examination

A multiple-tube fermentation test was carried out to find the total coliform count. Results were reported as MPN index [8-11].

2.4. MPN Analysis

2.4.1. Presumptive Method

This is the first section of MPN test. Presumptive test is used to detect presence of coliform bacteria in water sample. In this method 5 test tube in 3 sets all containing 10 ml of MacConkey broth media were prepared. First set of 5 tube contains double strength of MacConkey broth and rest two set of 5 tubes contain single strength of MacConkey broth media. For each three sets of five tubes, water samples were inoculated in the manner of 10 ml, 1 ml and 0.1 ml respectively. Durham tubes were put inside all 15 tubes to capture gas production. After this, tubes were incubated at 37°C for 48 hours. Tubes with positive results were noted and presumed coliform count per 100 ml. water had calculated using the probability table as shown in Table 4 [12, 13].

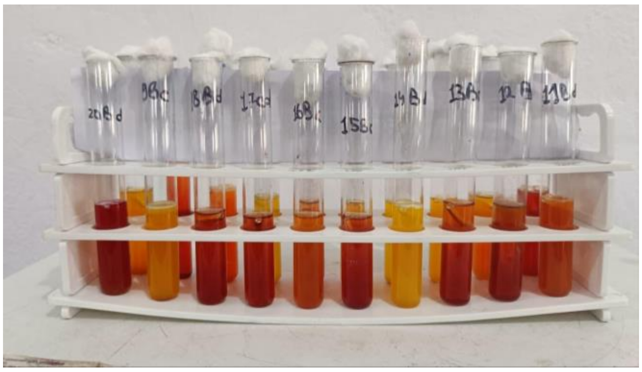

Figure 2. MPN tubes.

2.4.2. Confirmed Test

Second section of MPN analysis is confirmed test. Test tube with positive results were selected from presumptive test. A set of fresh Culture tube were prepared containing 10 ml. of Brilliant green bile broth (BGB HiMedia) and Durham tubes were put in each tube. 1 ml. of inoculum from Selected positive results test tube taken and inoculated into BGLB containing tube. Then these tubes were incubated at 37°C for 24-48 hrs.

2.4.3. Completed Test

Samples from the positive tube of presumptive test were inoculated into Eosin methylene blue Agar (EMB Agar HiMedia) plates by streaking method and incubated at 37°C for 24 hours. Colonies of *E. coli* appears as metallic sheen green colour. Other colonies of coliforms appeared were differentiated on the basis of colour.

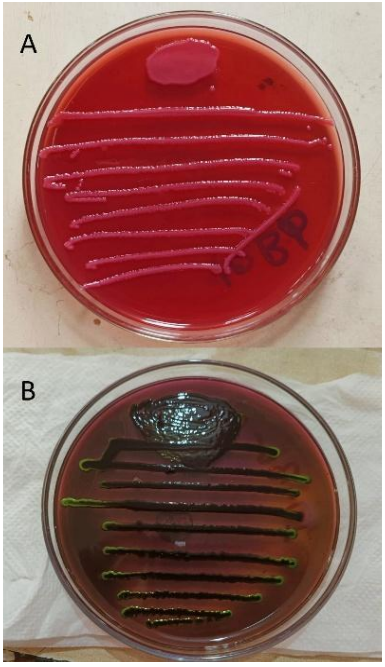

Figure 3. The culture plates of bacteria isolated form MPN tubes.

3. Results

After incubation, all tubes were observed for gas bubble formation or acid production. Number of tubes which shows positive results were noted for each set of 5 tube and combination were compared with MPN table as shown in Table 4. This was done for 3 seasons for all 25 water samples. MPN Index with total coliform count for 25 samples season wise are shown in Tables 1, 2 and 3.

Table 1. The MPN of pre-monsoon (summer).

Sample no.	MPN index	Total Coliform
BSII01	5 5 5	>1600
BSII02	5 2 2	94

Sample no.	MPN index	Total Coliform
BSII03	4 1 3	31
BSII04	4 1 0	17
BSII05	3 1 2	17
BSII06	2 3 1	14
BSII07	4 0 2	21
BSII08	2 3 1	14
BSII09	2 2 2	14
BSII10	3 4 1	24
BSII11	4 2 1	26
BSII12	2 2 2	14
BSII13	3 1 1	14
BSII14	4 1 1	21
BSII15	4 0 2	21
BSII16	2 3 0	12
BSII17	3 5 0	25
BSII18	4 2 2	32
BSII19	5 1 2	63
BSII20	5 0 3	58
BSII21	2 2 1	12
BSII22	2 2 2	14
BSII23	3 1 2	17
BSII24	4 0 2	21
BSII25	5 2 3	120

Table 2. The MPN of monsoon season.

Sample no.	MPN index	Total Coliform
BMII01	5 5 5	>1600
BMII02	5 5 5	>1600
BMII03	5 5 5	>1600
BMII04	5 5 5	>1600
BMII05	5 5 5	>1600
BMII06	5 5 5	>1600
BMII07	5 5 5	>1600
BMII08	5 5 5	>1600
BMII09	5 5 5	>1600
BMII10	5 5 5	>1600
BMII11	5 5 5	>1600
BMII12	5 5 5	>1600
BMII13	5 5 5	>1600
BMII14	5 5 5	>1600
BMII15	5 5 5	>1600
BMII16	5 5 5	>1600
BMII17	5 5 5	>1600
BMII18	5 5 5	>1600
BMII19	5 5 5	>1600
BMII20	5 5 5	>1600
BMII21	5 5 5	>1600
BMII22	5 5 5	>1600
BMII23	5 5 5	>1600
BMII24	5 5 5	>1600
BMII25	5 5 5	>1600

Table 3. The MPN of post-monsoon (winter).

Sample no.	MPN index	Total Coliform
BWII01	3 0 0	8
BWII02	5 0 0	23
BWII03	5 1 0	33
BWII04	4 1 0	17
BWII05	4 0 0	13
BWII06	5 0 1	31
BWII07	4 1 0	34
BWII08	5 1 1	46
BWII09	5 0 0	23
BWII10	5 0 0	23
BWII11	4 0 0	17
BWII12	4 0 3	25
BWII13	5 5 0	240
BWII14	5 5 0	240
BWII15	5 4 0	130
BWII16	5 0 0	23
BWII17	4 0 0	13
BWII18	5 0 3	58
BWII19	5 5 5	>1600
BWII20	5 5 0	270

Sample no.	MPN index	Total Coliform
BWII21	5 0 0	23
BWII22	5 1 1	46
BWII23	5 0 0	23
BWII24	5 0 0	23
BWII25	5 5 0	240

Table 4*. The reference table for the estimation of total coliform count from the MPN method.*

Combination of positives	MPN index/100 ml	95% confidence limits	
		Lower	Upper
0-0-0	<2	-	-
0-0-1	2	1.0	10
0-1-0	2	1.0	10
0-2-0	4	1.0	13
1-0-0	2	1.0	11
1-0-1	4	1.0	15
1-1-0	4	1.0	15
1-1-1	6	2.0	18
1-2-0	6	2.0	18
2-0-0	4	1.0	17
2-0-1	7	2.0	20
2-1-0	7	2.0	21
2-1-1	9	3.0	24
2-2-0	9	3.0	25
2-3-0	12	5.0	29
3-0-0	8	3.0	24
3-0-1	11	4.0	29
3-1-0	11	4.0	29
3-1-1	14	6.0	35
3-2-0	14	6.0	35
3-2-1	17	7	40
4-0-0	13	5	38
4-0-1	17	7	45
4-1-0	17	7	46
4-1-1	21	9	55
4-1-2	26	12	63
4-2-0	22	9.0	56
4-2-1	26	12	65
4-3-0	27	12	67
4-3-1	33	15	77
4-4-0	34	16	80
5-0-0	23	9.0	86
5-0-1	30	10	110
5-0-2	40	20	140
5-1-0	30	10	120
5-1-1	50	20	150
5-1-2	60	30	180
5-2-0	50	20	170
5-2-1	70	30	210
5-2-2	90	40	250
5-3-0	80	30	250
5-3-1	110	40	300
5-3-2	140	60	360
5-3-3	170	80	410
5-4-0	130	50	390
5-4-1	170	70	480
5-4-2	220	100	580
5-4-3	280	120	690
5-4-4	350	160	820
5-5-0	240	70	940
5-5-1	300	100	1300
5-5-2	500	200	2000
5-5-3	900	300	2900
5-5-4	1600	600	5300
5-5-5	≥1600	-	-

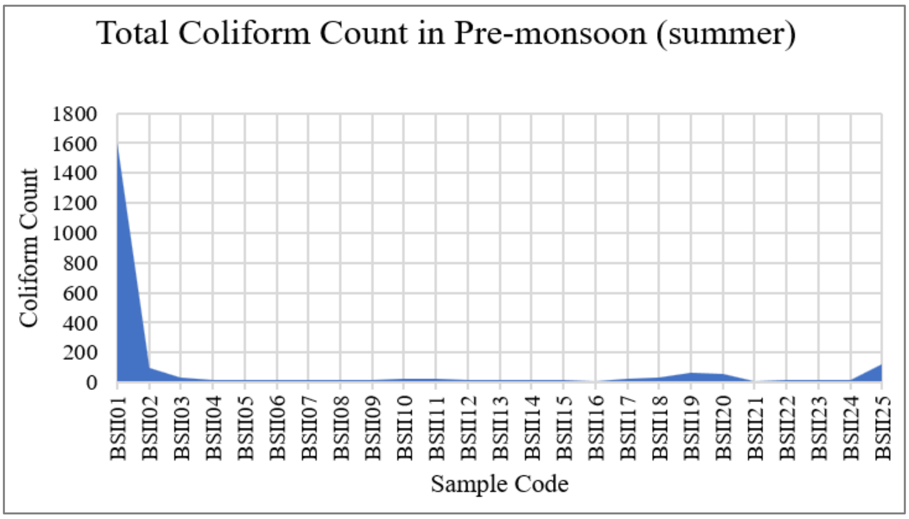

Figure 4. The graphical representation of total coliform count for pre monsoon season.

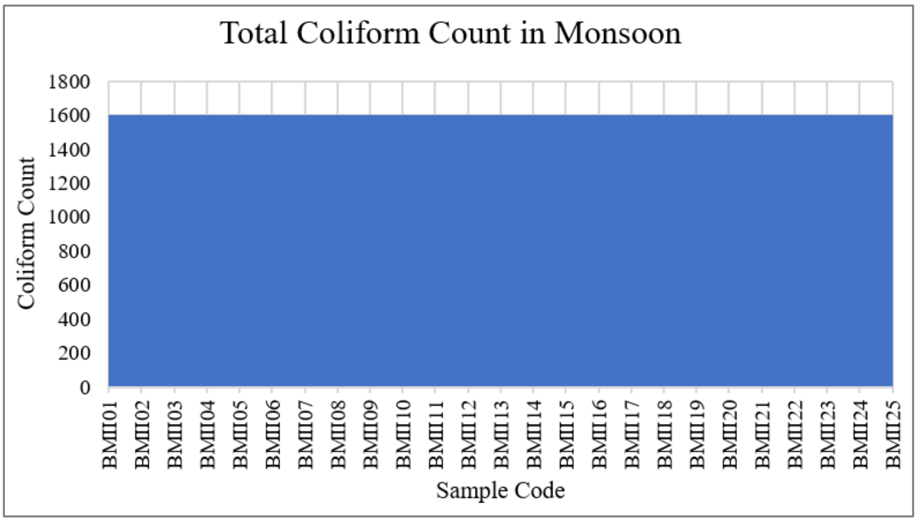

Figure 5. The graphical representation of total coliform count for monsoon season.

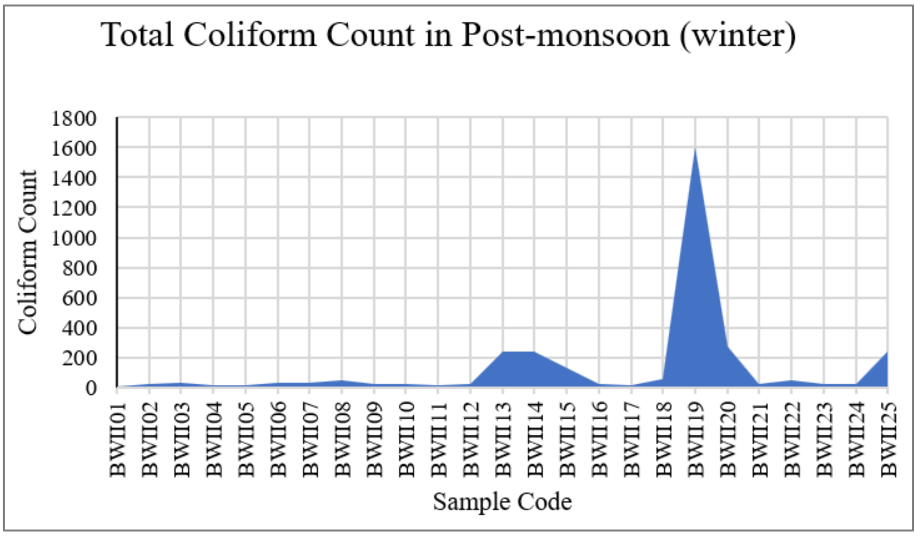

Figure 6. The graphical representation of total coliform count for post monsoon season.

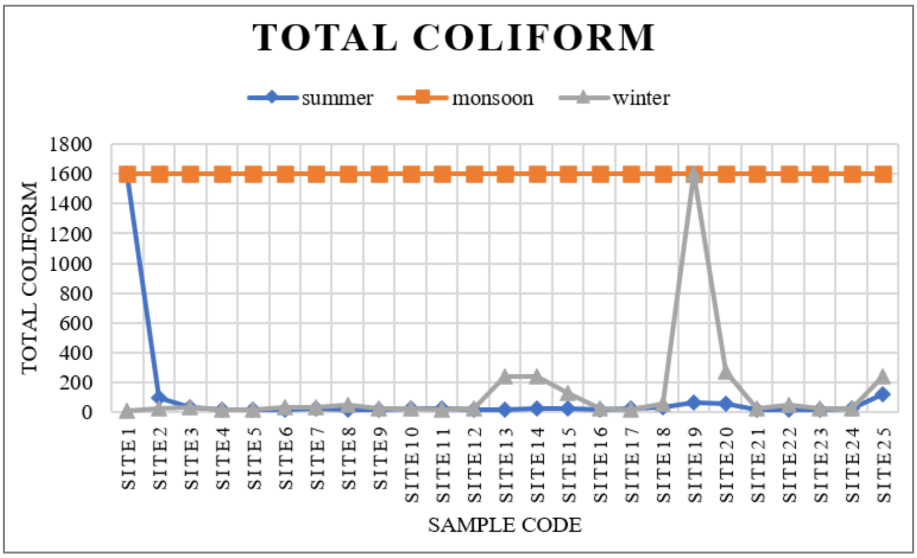

Figure 7. *Comparative graph for total coliform for all three seasons.*

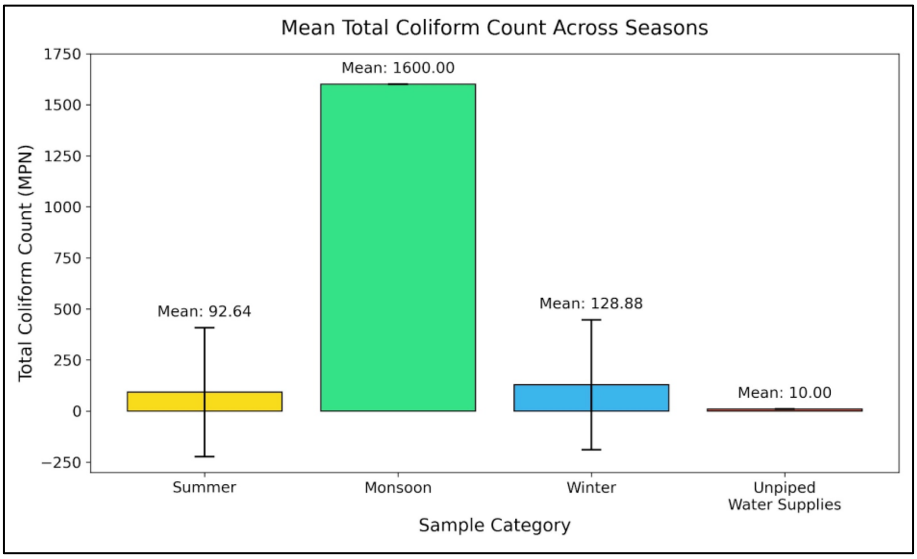

Figure 8. *Comparative graph for total coliform for all three seasons analysing mean count ± SD (standard deviation) where the mean total coliform count for unpiped water supplies according to WHO is 10 ± 0.0.*

Table 5. *The table presents the mean and standard deviation among the different seasons with WHO recommended parameter for unpiped water supplies.*

Season	Mean	Standard Deviation (SD)
Pre-monsoon	92.64	± 315.15
Monsoon	1600.0	± 0.00
Post-monsoon	128.88	± 317.77
Unpiped water supplies	10.0	± 0.00

4. Discussion

Bacteriological analysis of water using the MPN method showed severe contamination in most of the samples. The study results show that 100% of sample sources were contaminated with coliform and unsafe for drinking [14, 15]. For summer (pre-monsoon) MPN values were in ranges of 12 to 1600. Site 1 shows maximum coliform density (<1600) whereas site 16 and 21 show moderate coliform counts between 12 to 32. During monsoon contamination range for every 25 sites shows extreme concentration of >1600 MPN/100 ml.

In winter, the contamination range varies from a lower value of 8 (site-1) to a maximum of 1600 (site 19). Sites 13, 14, and 25 show high concentrations (240), site 20 (270) and site 19 show maximum concentration of 1600. Sampling sites were located within 20–700-meter radius of the Ramchak-Bairiya MSW dumping site. Open dumps generate heavy amounts of leachate form during rain water percolation. The presence of coliform bacteria in the sample clearly indicates that the source is contaminated. Their presence found in all three seasons confirm that this leachate severely impacted neighbouring shallow aquifers [16].

Due to heavy precipitation during monsoon creates massive volume of leachate, while simultaneously raising the water table with the mean value of 1600.00 and SD of ± 0.00. The rainwater drives rapidly flushing coliform directly into groundwater. Results reveal all 25 samples show maximum concentration. In winter season, i.e., post-monsoon, heavy rain stops, but groundwater remains contaminated with mean value of 128.88 and SD of ± 317.77. In summer, lack of rainfall limits new leachate generation and percolation lowers the mean deviation to 92.64 and SD of ± 315.15. Temperature and lower water table cause significant drop in coliform population. This indicates that comparatively, monsoons have the highest mean deviation and contamination among the three seasons, followed by post-monsoon (winter) and the lowest in pre-monsoon (summers) as shown in the Table 5 and Figure 8.

5. Conclusions

This study highlights that drinking water available to the residents near Ramchak-Bairiya MSW dumping site is highly contaminated. Total coliform must be absent in any 100 ml sample of drinking water and up to 10 coliform per 100 ml of water for unsupplied water supply [1, 17] according to WHO & BIS standards. Consumption of contaminated water poses severe risks of waterborne diseases to the residents. This study recommended immediate water treatment before drinking. Water must be treated via boiling, chlorination, filtration, etc. The Ramchak-Bairiya site should have a dedicated leachate collection and treatment system to stop groundwater percolation. Drinking water sources should be monitored regularly for their microbial quality to prevent outbreaks of enteric diseases [18].

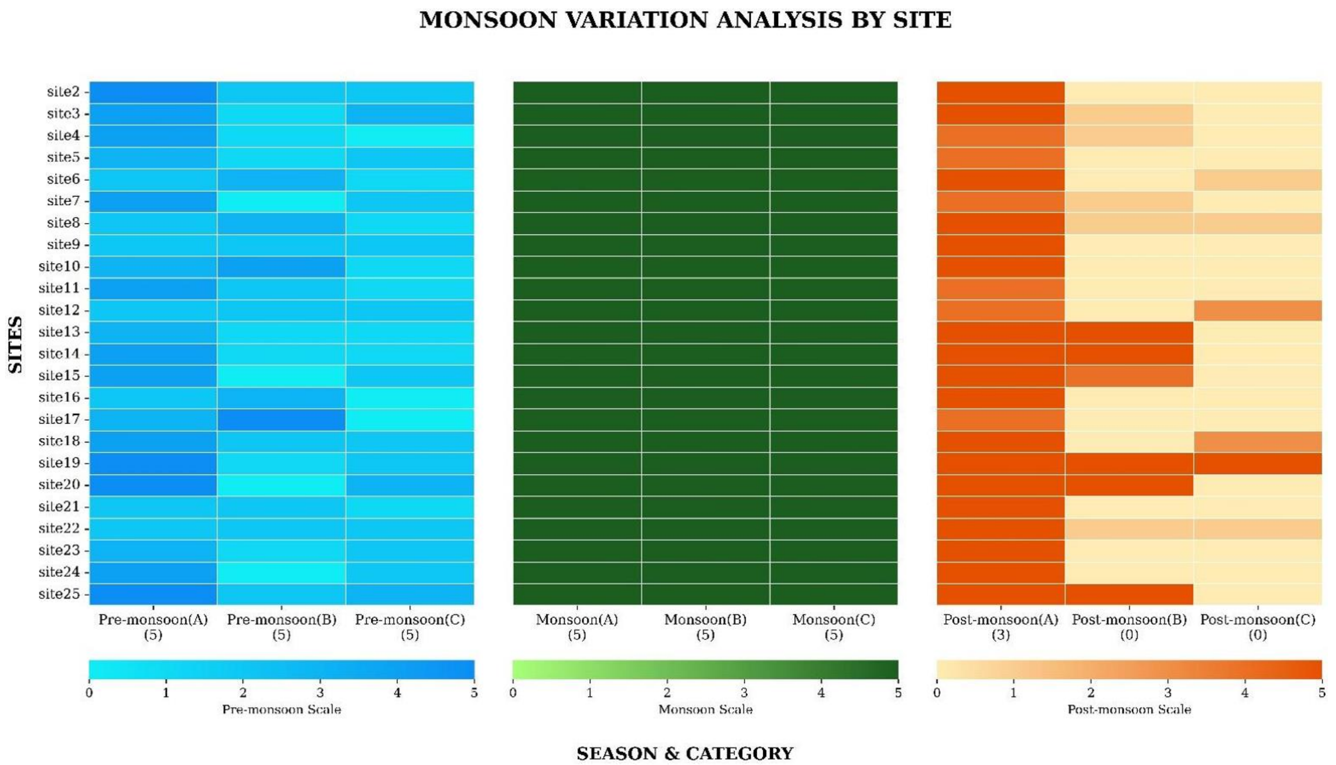

Figure 9. *The heatmap showing the MPN count for all 3 sets of tests for all three seasons.*

Abbreviations

WHO	World Health Organization
BIS	Bureau of Indian Standards
MSW	Municipal Solid Waste
MPN	Most Probable Number

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Author Contributions

Sweta Bharti: Conceptualization, Data curation, Methodology, Writing – original draft
Sushil Kumar Singh: Supervision, Validation
Shreyansh: Data curation, Methodology, Validation, Writing – original draft
Aparna Anand: Data curation, Methodology, Validation
Prem Mishra: Data curation, Validation, Writing – original draft

Conflicts of Interest

The authors declare no conflicts of interest.

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