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Research Article

Impact of Municipal Solid Waste Landfill Leachate on Groundwater Quality: A Case Study of Ramchak-Bairiya, Patna, Bihar

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Abstract

Major source of drinking water in the Patna region is ground water. This study focuses on assessing the impact of Municipal solid waste on ground water quality near around dumping site area in the Ramchak-Bairiya, Patna, Bihar, India. Dumping sites are in a risk zone of spilling of leachate through adjacent soil which leads to contaminated ground water. Surrounding area of dumping site can be a serious threat to the human health and environment. Huge quantity of municipal solid waste (MSW) dumps containing hazardous materials are a serious threat to the surrounding population of Patna. When these MSW are dumped at site, ground water began contaminating due to percolation of leachate to the porous ground surface. This leachate contains large number of contaminants which can pollute ground water. Ground water samples of different location adjacent to dumping sites were analyzed for microbiological, biochemical characterization, most probable number estimation and antibiotic sensitivity testing of isolated bacteria. The result of MPN test reveals heavy bacterial load in several sampling site which clearly indicates bacterial contamination inside source ground water. Presence of coliform confirms leachate infiltration into the ground water. Antibiotic susceptibility testing demonstrates a pattern of resistance against selective antibiotics. This may suggest the evolve of multidrug resistance (MDR) bacteria in contaminated ground water. Present investigation concludes that leachate of MSW from the Ramchak-Bairiya MSW dumping site severely contaminate the adjacent ground water quality, leading to serious Public health and environmental risks.

Keywords

Municipal Solid Waste, Leachate, Ground Water, Coliform, Multi Drug Resistance, Most Probable Number, Bacteriological

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1. Introduction

Aquifer is geological formation of groundwater [1, 2]. Primary source of drinking water in Bihar is groundwater, one of the major threats to groundwater are landfills. In developing nations like India, disposing of solid waste through land filling is considered as simplest, cheapest and cost-effective method. [3]. Solid wastes are discarded material. Solid waste may be classified on the basis of source as municipal solid waste, industrial solid waste, agriculture solid waste, mining and mineral solid waste, construction and demolition waste, healthcare waste, radioactive waste, human and animal waste [4]. Municipal solid waste contains food waste, paper, plastic rags, metal and glass etc. It can be hazardous and considered as dangerous waste [5]. In India the cheapest and most common method for waste disposal is dumping on unused land. MSW when disposed, it produces a liquid known as Leachate. Leachate are the major threat to water resources, human health & sanitation [6, 7]. For maintaining human health and the stability of ground water ecosystem. It is essential that water quality should be monitored regularly [8].

In Bihar, MSW is disposed without proper manual in low lying area like Ramchak-Bairiya. It results in open dumps that are called landfill sites. This leads to the contamination of ground water, affects the environment and human health. For preventing contamination of aquifer, proper evaluation of quality of ground water, along with planning and building of water resources is needed. The effect of depth and distance of dumping site from ground water sources were studied. Present investigation is for assessing the bacteriological analysis of ground water around the MSW dumping site in Ramchak-Bairiya, Patna, Bihar.

2. Materials and Methods

2.1. Study Area

The present study was conducted at the dumping site of MSW in Ramchak-Bairiya, Patna, Bihar. Patna is located on 25°6” N latitude and 85°1” E longitude at an altitude of elevation 174 mt above mean sea level in the Figure 1. Patna Municipal Corporation covers an area of 109 sq. km and had a population of 1684297 people according to the 2011 census of India. Patna generates about 1200 metric tons of MSW daily with organic waste. This area was selected because Ramchak-Bairiya is one of the largest dumping sites of MSW in the city. The Patna Municipal corporation dumps its waste here which is surrounded by heavy population. The area is having recent urban sprawl, the area is of old alluvial flood plain having a 300 m layer of soil the area have two aquifers separated by a clay layer of 2-5 m the top aquifer rely on monsoon for its recharge while the deep aquifer is recharged by the Ganga river [9]. Study was conducted to evaluated to evaluate the effect of leachate and ground water quality on human health.

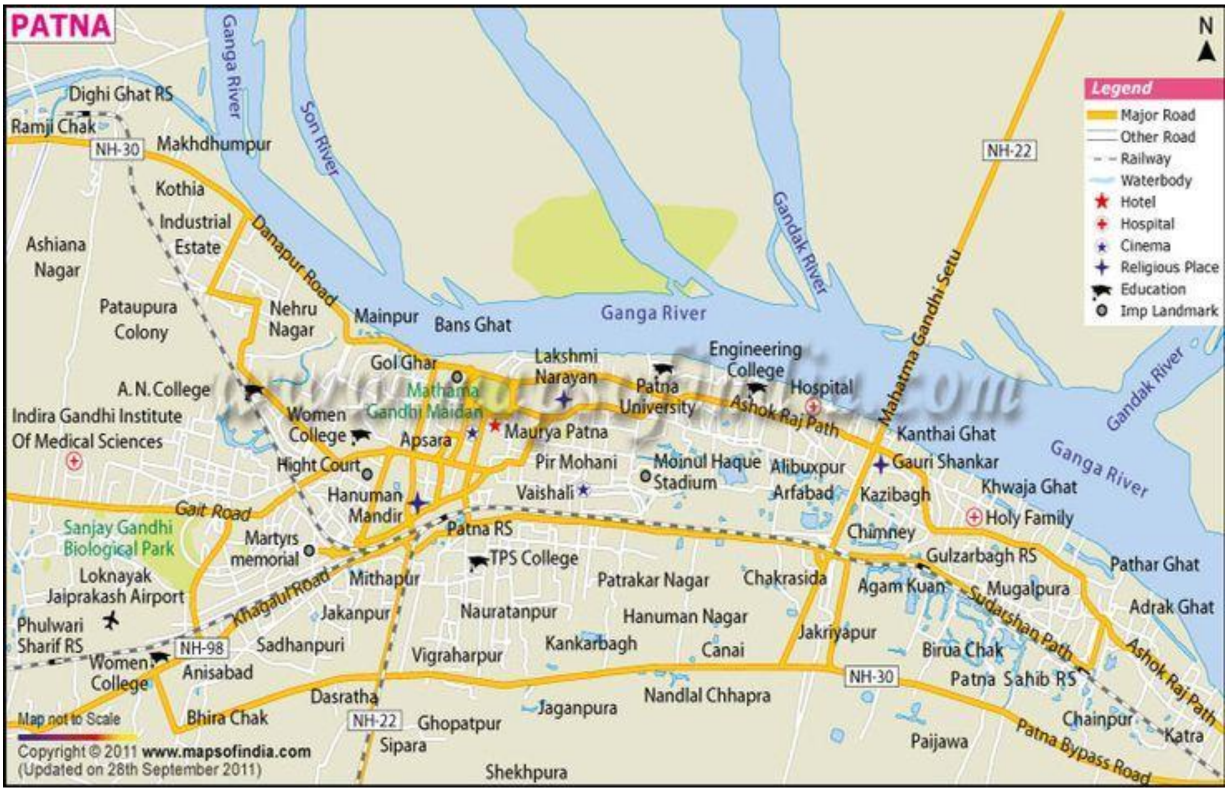

Figure 1. *Study map of Patna Municipal Corporation.*

2.2. Sample Collection

For microbiological study around water samples were collected from selected locations with distances ranging from 150 m to 750 m and well depth of 50 m to 80 m near around the dumping site. Cleaned sterile 100 ml sample collection containers used for collection of water sample, further sealing with parafilm and transported to Department of Biotechnology, A. N. College, Patna laboratory in the ice box. the readers.

2.3. MPN

For estimation of total coliform present in the samples, MPN test was performed.

2.4. Bacterial Isolation

Bacterial colonies isolated from sample using selective media MacConkey and EMB agar. Colonies with different morphology, pattern, and texture was selected and subject to characterized using standard biochemical test which include Indole, Methyl red, Vogas Proskauer, Citrate utilization, Oxidase, Urease and catalase test [10, 11].

2.5. Antibiotics Susceptibility Test

Bacterial isolates were tested for their antibiotic susceptibility by using disc diffusion method. Zone of inhibition was recorded for each isolate and list of antibiotics used as shown in the Table 1.

Table 1. *A table enlisting antibiotic with abbreviation and concentration.*

S. No.	Abbreviation	Antibiotics	Concentration in mcg
1	A/S	Ampicillin/Sulbactam	10/10
2	C	Chloramphenicol	30
3	CIP	Ciprofloxacin	5
4	E	Erythromycin	15
5	GEN	Gentamicin	10
6	LF	Levofloxacin	5
7	OF	Ofloxacin	5
8	TE	Tetracycline	30

3. Results

3.1. Total Coliform Count

MPN analysis confirm adequate coliform contamination in ground water. Many sampling sites shows significant population of coliform in culture tubes. MPN results are shown in Table 2.

Table 2. *The MPN values of the sites.*

S. No.	Sample	MPN Index	Total Coliform
1	BI01	1-3-1	10
2	BI02	4-0-3	25
3	BI03	5-0-1	31
4	BI04	4-1-1	21
5	BI05	3-2-0	14
6	BI06	4-2-3	38
7	BI07	4-3-1	33
8	BI08	4-5-1	48
9	BI09	3-5-0	25
10	BI10	4-2-2	32
11	BI11	3-2-0	14
12	BI12	3-5-0	25
13	BI13	5-4-0	130
14	BI14	5-4-2	220
15	BI15	5-2-4	150
16	BI16	3-5-0	25
17	BI17	3-2-0	14
18	BI18	5-0-3	58
19	BI19	5-4-3	280
20	BI20	5-3-4	210
21	BI21	3-3-2	24
22	BI22	5-2-0	49
23	BI23	4-0-2	21
24	BI24	5-0-1	31
25	BI25	4-5-1	48

3.2. Bacterial Characterization

Bacterial colonies isolated from selective media plates were characterized by different biochemical test as shown in the Table 3. Result confirms the presence of dominant faecal coliform in the sample.

3.3. Antibiotic Susceptibility

Antibiotic susceptibility test shows variable resistance patterns among isolated bacterial colonies. Multidrug resistance

(MDR) patterns are shown in Table 4.

Table 3. *The prediction of probable bacteria on the basis of biochemical tests.*

S. No.	Sample	Indole	MR	VP	Citrate	Oxidase	Urease	Catalase	Probable Bacteria
1	SWA1	+ve	+ve	+ve	+ve	+ve	+ve	+ve	*Aeromonas* spp.
2	SWA2	+ve	-ve	+ve	+ve	+ve	+ve	+ve	*Aeromonas* spp.
3	SWA3	+ve	-ve	+ve	+ve	-ve	+ve	+ve	*Klebsiella oxytoca*
4	SWA4	+ve	-ve	+ve	+ve	-ve	+ve	+ve	*Klebsiella oxytoca*
5	SWA5	+ve	-ve	+ve	+ve	-ve	+ve	+ve	*Klebsiella oxytoca*
6	SWA6	+ve	-ve	+ve	+ve	-ve	+ve	+ve	*Klebsiella oxytoca*
7	SWA7	+ve	-ve	+ve	+ve	-ve	+ve	+ve	*Klebsiella oxytoca*
8	SWA8	+ve	-ve	+ve	+ve	-ve	+ve	+ve	*Klebsiella oxytoca*
9	SWA9	+ve	+ve	-ve	-ve	+ve	+ve	+ve	*Aeromonas* spp.
10	SWA10	+ve	+ve	-ve	+ve	-ve	Delay	+ve	*Citrobacter koseri*
11	SWA11	+ve	+ve	-ve	-ve	-ve	+ve	+ve	*Escherichia coli*
12	SWA12	+ve	+ve	-ve	+ve	-ve	Delay	+ve	*Citrobacter koseri*
13	SWA13	+ve	+ve	-ve	-ve	-ve	+ve	+ve	*Escherichia coli*
14	SWA14	+ve	-ve	+ve	+ve	-ve	+ve	+ve	*Klebsiella oxytoca*
15	SWA15	+ve	+ve	-ve	+ve	-ve	+ve	+ve	*Proteus* spp.
16	SWA16	+ve	+ve	+ve	-ve	-ve	-ve	+ve	*Escherichia coli*
17	SWA17	+ve	+ve	+ve	-ve	-ve	-ve	+ve	*Escherichia coli*
18	SWA18	+ve	+ve	-ve	-ve	-ve	+ve	+ve	*Escherichia coli*
19	SWA19	+ve	+ve	-ve	-ve	-ve	+ve	+ve	*Escherichia coli*
20	SWA20	+ve	+ve	-ve	-ve	-ve	+ve	+ve	*Escherichia coli*
21	SWA21	+ve	-ve	+ve	+ve	-ve	+ve	+ve	*Klebsiella oxytoca*
22	SWA22	+ve	+ve	-ve	-ve	-ve	+ve	+ve	*Escherichia coli*
23	SWA23	+ve	+ve	-ve	+ve	+ve	+ve	+ve	*Aeromonas* spp.
24	SWA24	+ve	+ve	-ve	-ve	-ve	+ve	+ve	*Escherichia coli*
25	SWA25	+ve	+ve	-ve	-ve	+ve	Delay	+ve	*Aeromonas* spp.
26	SWA26	+ve	+ve	-ve	+ve	+ve	+ve	+ve	*Aeromonas* spp.
27	SWA27	+ve	-ve	+ve	+ve	-ve	+ve	+ve	*Klebsiella oxytoca*

Table 4. *Antibiotics Sensitivity Test for different isolates from the dumping area.*

S. No.	Sample	AMP	C	CIP	E	GEN	LE	OF	TE
1	SWA1	12	12	30	20	30	22	11	6
2	SWA2	12	28	34	13	35	26	22	22
3	SWA3	2	24	40	22	42	28	25	24
4	SWA4	17	18	34	22	25	24	22	17

S. No.	Sample	AMP	C	CIP	E	GEN	LE	OF	TE
5	SWA5	16	17	35	18	36	24	24	24
6	SWA6	17	25	30	22	30	23	15	17
7	SWA7	15	22	33	16	40	26	22	17
8	SWA8	6	18	31	8	45	22	22	6
9	SWA9	16	22	34	16	30	25	22	22
10	SWA10	17	15	30	14	35	22	19	22
11	SWA11	6	20	35	15	32	23	17	6
12	SWA12	18	32	37	17	31	25	22	24
13	SWA13	6	16	33	18	30	20	19	21
14	SWA14	6	12	25	13	30	17	18	13
15	SWA15	20	20	32	13	20	24	21	24
16	SWA16	16	27	35	10	6	20	16	20
17	SWA17	16	22	32	27	40	22	22	24
18	SWA18	20	20	30	17	40	22	22	22
19	SWA19	17	24	32	21	40	24	22	22
20	SWA20	15	28	28	17	35	24	22	24
21	SWA21	17	22	25	12	42	21	17	19
22	SWA22	16	20	30	20	31	22	18	20
23	SWA23	16	16	28	12	34	20	17	22
24	SWA24	19	16	30	11	31	20	18	15
25	SWA25	17	28	30	20	34	20	16	22
26	SWA26	6	6	26	15	36	20	15	30
27	SWA27	15	29	34	16	37	23	15	32

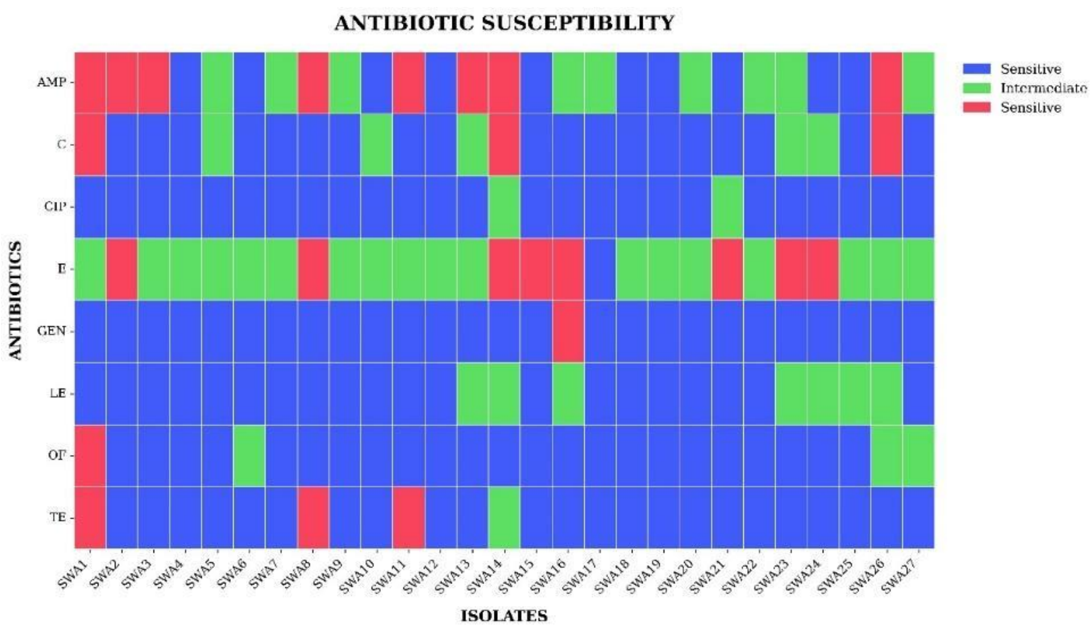

Figure 2. *The heatmap representing the antibiotics resistance of the bacterial isolates.*

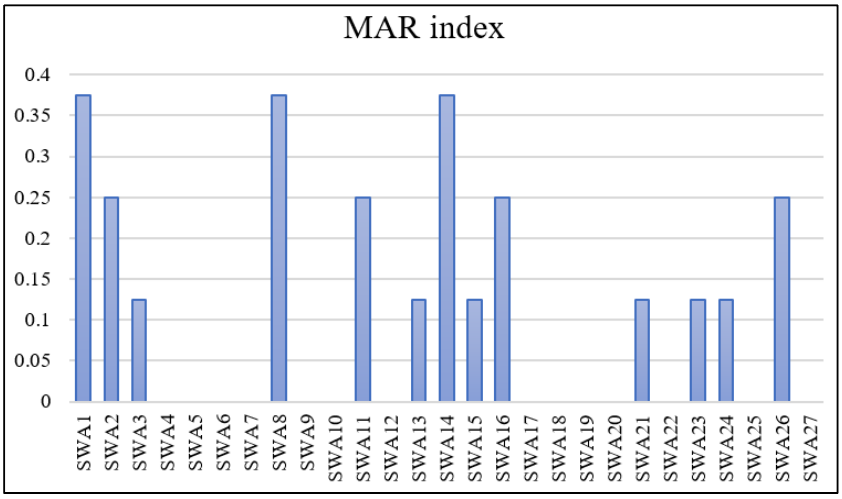

***Figure 3**. The graphical representation of MAR of the bacterial isolates.*

4. Discussion

A total of 25 ground water samples from different houses residing in close vicinity of dumping site of Ramchak-Bairiya, Patna, Bihar were collected in clean, sterilized container and were brought to A. N. College laboratory for analysis [12, 13]. The data showed that there was considerable variation in different samples with respect to their bacteriological characteristics.

Almost all water samples contain significant amount of organic matter that provides nutrition for the growth and multiplication of microorganisms [14]. This study has shown MPN values at the range of > 1600 coliform per 100 ml of water sample which indicates contamination of ground water. Coliform used as bacterial indicator of water quality is based on fact that coliforms habituated in high numbers in the faeces of human and other warm-blooded animals. Sample which shows presence of coliform indicating the contamination of ground water due to leachate percolation.

Antibiotic susceptibility test shows high level of resistance, particularly against Ampicillin. Presence of resistive bacteria in the ground water may cause serious health risk to population due to its ability to spread through drinking water. MDR pattern observed suggest long term exposure of microorganism to contaminated waste environments.

5. Conclusions

This study shows microbial contamination in the ground water adjacent to Ramchak-Bairiya MSW dumping site. Diverse biochemical result reveals the presence of mixed microbial population such as *Aeromonas, Klebsiella, Proteus, E. coli* species. High MPN values confirm coliform contamination.

Ramchak-Bairiya MSW dumping site is un-engineered, unplanned site which have not any bottom liner or leachate collection facility and treatment system. Due to this leachate generated flow to surrounding environment. In these condition, major steps could be followed are (i) by providing impermeable clay cover we can limit the infiltration of the water through the landfill. (ii) a proper vegetation cover over the landfill increasing the evapo-transpiration rate which reduce leachate production.

This study suggests for regular monitoring of quality of ground water including physico-chemical, heavy metals polycyclic aromatic hydrocarbon, chlorides and others contaminants along with air quality. Public awareness, installation of proper leachate collection and treatment system, proper segregation and disposal of MSW.

Abbreviations

MSW	Municipal Solid Waste
MDR	Multidrug Resistance
MPN	Most Probable Number
Mcg	Microgram
MAR	Multiple Antibiotic Resistance

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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, Methodology, Validation

Conflicts of Interest

The authors declare no conflicts of interest.

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