International Journal of Innovation and Scientific Research
ISSN 2351-8014 Vol. 49 No. 1 Jun. 2020, pp. 124-136

http://www.ijisr.issr-journals.org/

Geospatial, Statistical and Human Health Risk Assessment of Groundwater Contamination Around Waste Disposal Site at Khulna in Bangladesh

Md. Refat Hossain[1] and Khondoker Mahbub Hassan[2]

[1]Post Graduate Student, Dept. Of CE, Khulna University of Engineering & Technology, Khulna-9203, Bangladesh

[2]Professor, Dept. Of CE, Khulna University of Engineering & Technology, Khulna-9203, Bangladesh

ABSTRACT: Abstract Groundwater is an essential source of drinking purpose. Groundwater samples were collected from tube-wells from Rajbandh, Khulna dumping site as well as its adjoining area to find out the level of concentration of different water quality parameters. In order to find out the strength and the linear relationship between different pairs of parameters as well as to predict the level of pollution of groundwater, statistical analysis had been done. The significance level further verified by t-test. The effect of heavy metal on human body can spread risk. That's why risk assessment was done on those parameters which were exceeded the allowable concentration level referred by The Environment Conservation Rules (ECR) (1997) according to USEPA guidelines (1989) considering ingestion and dermal pathways. The chronic daily intake (CDI), hazard quotient (HQ), hazard index (HI) were evaluated. Furthermore, to check uncertainty of exposure parameters and risk values, Monte Carlo Simulation (MCS) was used. Central Tendency Exposure (CTE) and Reasonable Maximum Exposure (RME) as well as non-carcinogenic condition were used for MCS operation. Nine different water quality parameters were collected from four different locations since a period of 2018. In this study an appreciable strong positive correlation was found for E.C with turbidity, alkalinity; turbidity with alkalinity also for chloride with TDS. A strong negative correlation was found for ph with turbidity, alkalinity, E.C. Water Quality Index (WQI) was used to analyze the groundwater quality of study site. The test result reveals that 50% water samples were found poor quality and 50% samples were found unsuitable for drinking purposes. The WQI ranges from 72.998 to 164.332. Which further analyzed by ArcGIS. RME showed relatively more risk values than that of CTE values. Therefore, the overall assessment reveals that there is a need of some treatment before usage of water and also require to protect the area from landfill contamination.

KEYWORDS: Statistical analysis, Monte Carlo Simulation, WQI, ArcGIS.

1 INTRODUCTION

Municipal solid waste (MSW) disposal in the surrounding environment has increased a large amount due to rapid urbanization and industrialization. Disposal of solid waste and sewage, urban runoff, agricultural activities and polluted surface water are major contributors to deteriorate urban groundwater resources [1]. Groundwater are used for domestic and agricultural purposes. According to WHO organization, about 80% of all the diseases in human beings are caused by water. Landfills have been identified as one of the major threats to groundwater resources [2]. Water that has percolated through a solid and leached out some of the materials called leachate generates due to the decomposition of wastes. Leachate percolate the groundwater and causes contamination which pollute the drinking water and cause diseases among the dwellers around dumping site. Contamination of ground water by landfill can spread risk among the dwellers.

2 BACKGROUND

Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source [3]. So, continuously water quality monitoring is very much necessary. Generally, the laboratory methods are time consuming and very much costly so, some methods can develop which will provide easy, reliable and cost-effective methods to collect data and provide information of the level of pollution by different parameters [4]. For this reason, in recent years a very simple method track based on statistical correlation has been developed using mathematical relationship for comparison of physicochemical parameters **[5].** Risk analysis is a part of every decision we make. To assess health risk assessment water ingestion and dermal contact were considered according to USEPA guideline (1989). The chronic daily intake (CDI), hazard quotient (HQ), hazard index (HI) were determined. Health risk assessment procedure provides clear and systematic form of quantitative (or semi-quantitative) description of health and environment risk [6]. Risk analysis mainly done on children's because they behave differently from adults and they have very little control over environment. Children health problems occur frequently due to the contamination of drinking water. Central tendency exposure (CTE) and reasonable maximum exposure (RME) were considered for risk analysis and the differences are given in [7]. The numeric expressions for risk assessment obtained from the USEPA Risk methodology **[11].** Monte Carlo simulation (MCS) is a technique for characterizing variability and uncertainty by repeating of risk equation inputs. MCS can see all the possible outcomes of one's decisions and assess the impact of risk. The results of risk assessment should always contain both the "number" and the "measure of uncertainty" [8].

Khulna, Rajbandh zone was selected because city corporation solid waste is dumped in that area. So, it can be said that groundwater can normally be polluted in that area and people get affected by ingestion though people drink water from deep tube-well. For this study, four locations namely Hogladanga landfill (location 1), Joykhali landfill (location 2), Progoti Secondary School, Hogladanga (location 3), R.S.O Hasari and Culture station (location 4) were selected.

3 MATERIALS AND METHODS

3.1 STUDY AREA

Khulna Rajbandh location was selected for this study. It is 8 km far from the city center. Groundwaters were collected from tube-wells from 4 locations around landfill site.

Location: Latitude: 22º47'43.17" and Longitude: 89º29'58.35"

Fig. 1. Selected study area at Rajbandh from google earth

3.2 ANALYTICAL METHOD

After the sampling, the samples were immediately transferred to the laboratory and were stored in Refrigerator. The analysis was started without any delay in the lab based on APHA (1994) methods. All the samples like physico-chemical parameters, heavy metals and total coliform (TC) and faecal coliform (FC) were analyzed by APHA (1994) methods. In case of physico-chemical parameters includes color, nitrate (NO3-) (reagent: nitaver 3 Nitrate), Electro-conductivity (EC) (instrument: EC meter), phosphate (PO43-) (reagent: phosver 3 Phosphate), sulphate (SO42-) (reagent: sulfaver 4 sulfate) were tested by DR2700 Spectrophotometer. On the other hand, in case of heavy metals includes arsenic (As) (reagent: sulfonic acid and zinc powder, method: strip test method), iron (Fe) (reagent: ferrover Iron), manganese (Mn) (reagent: buffer powder citrate and sodium periodate) were tested by DR2700 Spectrophotometer (Preprogrammed methods: >130 Pre-programmed Water Analysis methods, Wavelength accuracy: +/- 1.5 nm, wavelength range: (400-900) nm). Zn, Cu were tested by AA 7000 Series Atomic Absorption Spectrophotometers. Ph was tested by ph meter. Turbidity was tested by Turbidimeter. Hardness, chloride (Cl-), alkalinity was tested by titration. COD was tested by closed reflux method and was used COD calibration curve. TC and FC were tested by membrane filtration method. TDS was tested by gravimetric method. BOD test was done by 5-days BOD test method.

3.3 STATISTICAL ANALYSIS

The correlation between various physicochemical parameters of water samples were analyzed statically conducting Pearson correlation through Microsoft Excel by equation (1).

$$R = \frac{n\,(\sum xy) - \sum x * \sum y}{\sqrt{[n \sum x^2 - (\sum x)^2] * [n \sum y^2 - (\sum y)^2]}} \qquad (1)$$

Where,

X = Individual reading of 1st parameter
Y = Individual reading of 2nd parameter
N = number of values of single parameter

The correlation among the different parameters will be true when the value of correlation coefficient (r) is high and approaching to one [9]. Correlation, the relationship between two variables, is closely related to prediction. The greater the association between variables, more accurately can predict the outcome of events **[5].**

T TEST

For checking the significance t-test was conducted and the formula is given below by equation (2):

$$T = \frac{|\overline{x1} - \overline{x2}|}{\sqrt{\frac{S1^2}{n1} + \frac{S2^2}{n2}}} \qquad (2)$$

^{2} = average value of 2nd parameter
N1 = number of reading of 1st parameter
N2 = number of reading of 2nd parameter
S1 = standard deviation of 1st parameter
S2 = standard deviation of 2nd parameter

In case of standard deviation, the formula is given below by equation (3):

$$S = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}} \qquad (3)$$

3.4 DRINKING WATER QUALITY INDEX (DWQI)

The WQI was initially invented by Brown et.al (1970) and then modified by Backman et.al (1998)). Each of the parameters has been assigned according to its relative importance in the overall quality of water for drinking purposes. The relative weight was computed using the following equation (4):

$$W_i = \sum \frac{wi}{\sum_{i=1}^{n} wi} \quad (4)$$

Where,

W_i = relative weight of each parameter
W_i = weight of each parameter
N = number of parameters

For each parameter, the quality rating scale was calculated by dividing its concentration in each water sample to its respective standards (released by World Health Organization 2011) (Edition 2011) and finally multiplied the results by 100 through equation (5).

$$q_i = \left(\frac{Ci}{Si}\right) x\ 100 \qquad (5)$$

Where,

Qi = the quality rating
Ci = concentration of each parameter (mg/L)
Si = standard limit (mg/L) according to WHO released in 2011

The quality of water is categorized into five types which is shown in table 1

Table 1. Rating of water quality index

WQI value	Rating of water quality	Grating
0-25	Excellent water quality	A
26-50	Good water quality	B
51-75	Poor water quality	C
76-100	Very poor water quality	D
Above 100	Unsuitable for drinking purposes	E

[10]

For computing of sub index of each parameter, weight (W_i) of each parameter is needed which is shown in table 2.

Table 2. The weight (w_i) and WHO standard values for drinking water

Parameters	Concentration (mg/L) (Ci)	WHO (mg/L) (Si)	Weight (wi)
Ph	7.64	6.5-8.5	4
E.C	1102	750	4
TDS	1280	500	4
Cl-	600	250	3
NO3-	0.15	10	5
Turbidity	3.01	4	3
Alkalinity	260	300	3
Mn	0.1	0.1	4
Fe	0.32	0.3	4
		Sum =	34

In the final stage of WQI computing the sii was first determined for each parameter and then the sum of si_i values gave the WQI for each sample shown in equations (6) & (7).

$$Si_i = Wi\ x\ qi \qquad (6)$$

Where, sii is the sub-index of each parameter

$$WQI = \sum_{i=1}^{n} SIi \qquad (7)$$

Where, WQI is the water quality index

3.5 Risk Assessment Process

The numeric expressions for risk assessment as obtained from the USEPA Risk Assessment Guidance for Superfund (RAGS) methodology **[11]** are given as follows:

$$CDI_{ing} = \frac{\text{Cw x WIR x ABSsx EF x ED}}{BW\ x\ AT} \qquad (8)$$

$$CDI_{derm} = \frac{Cw \ x \ SA \ x \ CF \ x \ PC \ x \ ABSs \ x \ ET \ x \ EF \ x \ ED}{BW \ x \ AT} \quad (9)$$

Where cdi_{ing} = chronic daily intake (mg/kg/day), C_w = metal concentration in water (mg/L), WIR = water ingestion rate (L/day), abss = absorption factor (%), SA = surface area available for contact (cm^2), CF = volumetric conversion factor for water (L/cm3), PC = metal specific dermal permeability constant (cm/hours), ET = exposure time (hours/event), EF = exposure frequency (days/year), ED = exposure duration (years), BW = body weight (kg), AT = average time (days).

The values of several factors (body weight, ingestion rate, body surface area etc) or parameters (contact frequency, contact duration, lifetime exposure) with various exposure pathways for Central Tendency Exposure (CTE) and Reasonable Maximum Exposure (RME) were followed by RAGS (USEPA, 1989). These exposure parameters have specified value for specific conditions is shown below:

Table 3. Values of exposure parameters for risk assessment used in this study

Exposure pathway	**Child**				**References**
	Variable	CTE value	RME value	Unit	
Water dermal contact	SA	5140	5140	Cm^2/event	USEPA Handbook 2001
	ABS	1	1	Unit less	
	ET	8	8	Hours/day	
	EF	200	225	Days/year	
	ED	5	5	Years	
	BW	13.2	13.2	Kg	
	AT	365*ED (non-carcinogenic condition)		Days	
Water ingestion	WIR	1.8	1.8	L/day	(RAGS, 2013)
	ABS	1	1	Unit less	USEPA Handbook 2001
	EF	200	225	Days/day	
	ED	6	6	Years	
	BW	13.2	13.2	Kg	
	AT	365*ED (non-carcinogenic condition)		Days	

The values of permeability constant (PC), rfds in case of dermal and ingestion for different heavy metals are given in table 4.

Table 4. Dermal permeability (PC) values and rfd for non-carcinogenic risk of different heavy metals

Parameters	**PC (cm/hr)**	**Rfding (mg/kg-day)**	**Rfdderm (mg/kg-day)**	**References**
As	1.00E-03	3.00E-03	1.23E-04	(Masok et.al, 2017) (Li & Zhang, 2010) (USEPA, 1989)
Fe	1.00E-03	9E-03	7E-01	
Mn	1.00E-03	4.60E-02	1.84E-03	

3.6 HEALTH RISK ASSESSMENT

The risk which can cause by physico-chemical parameters or heavy metals otherwise, biological parameters. The constituents which can bring risk among the dwellers around dumping site were identified by hazard quotient (HQ). The formula is given below:

$$HQ = \frac{dose}{RfD} \quad (10)$$

Where dose = cdiing / cdiderm values of different parameters, rfd = Reference dose. Hazard quotient greater than 1 provides evidence that a potential health risk associated with chronic exposure to a given substance does exist. Otherwise, it is assumed that the risk is at acceptable level **[8].**

To evaluate the overall potential for non-carcinogenic effects posed by more than one heavy metal, the computed hqs for each heavy metal are expressed as a Hazard Index (HI) by equation 11 [12].

$$\mathrm{HI}_{ing/derm} = \sum_{i=0}^{n} HQing/derm \qquad (11)$$

Where hiing/derm is hazard index via ingestion, dermal (unit less).

4 Results And Discussion

At first the concentration of water quality parameters was determined in the laboratory and compared with allowable limit referred by ECR (1997) for groundwater sample. The data are shown in Table 5

Table 5. Values of physicochemical parameters with Bangladesh standard

Items	Ph	Chloride (mg/L)	E.C (µs/cm)	Turbidity (NTU)	TDS (mg/L)	Alkalinity (mg/L)
Location 1	7.2	420	1400	4.44	860	295
Location 2	7.6	230	538	2.11	486	255
Location 3	7.64	600	1102	3.01	1280	260
Location 4	7.82	500	800	1.95	980	225
Sum	30.26	1750	3840	11.51	3606	1035
Average (X)	7.565	437.5	960	2.8775	901.5	258.75
Standard deviation (S)	0.261	156.710	373.0273	1.1413	328.5254	28.686
Variance	0.068	24558.333	139149.3	1.3027	107929	822.916
N	4	4	4	4	4	4
BD standard	6.5-8.5	150-600 (mg/L)	-µs/cm	10 NTU	1000 (mg/L)	200 (mg/L)

For the calculation of correlation coefficient and t-test, some calculation has already shown above table. Different pairs of water quality parameters with significant correlation coefficients are given in Table 6.

Table 6. Correlation between different pairs of parameters and t-test results

SL No	Pairs of Parameters	Correlation	T test	Significant or not significant (p<0.05)
1	Ph & Cl-	0.2216	5.4869	Significant
2	Ph & E.C-	-0.7024	5.1065	Significant
3	Ph & Turbidity	-0.9201	8.0063	Significant
4	Ph & Alkalinity	-0.9721	17.5117	Significant
5	Ph & TDS	0.1901	5.4421	Significant
6	Cl- &E.C	0.5299	2.5827	Significant
7	Cl- &Turbidity	0.1779	5.5467	Significant
8	Cl- & Alkalinity	-0.1306	2.2439	Not Significant
9	Cl- & TDS	0.9929	2.5495	Significant
10	E.C & Turbidity	0.9227	5.1316	Significant
11	E.C & Alkalinity	0.7198	3.7487	Significant
12	E.C & TDS	0.5392	0.2354	Not significant
13	Turbidity & Alkalinity	0.9263	17.8251	Significant
14	Turbidity & TDS	0.2056	5.4706	Significant
15	Alkalinity & TDS	-0.0750	3.8981	Significant

In the present study, ph has strong significant negative correlation with E.C ($r = -0.7024$, $t = 5.1065$), turbidity ($r = -0.9201$, $t = 8.0063$). The chloride has weak negative correlation with alkalinity ($r = -0.1306$, $t = 2.2439$); weak correlation for alkalinity with TDS ($r = -0.0750$, $t = 3.8981$) also ph has strong negative correlation with alkalinity ($r = -0.9721$, $t = 17.5117$). This shows that with any increase or decrease in the values of ph; electrical conductivity (E.C), turbidity, alkalinity exhibit decreases or increase in their values.

EC shows significant strong positive correlation with turbidity (r = 0.9227, t = 5.1316), alkalinity (r = 0.7198, t = 3.7487) also for chloride with TDS (r = 0.9929, t = 2.5494). Turbidity shows significant strong positive correlation with alkalinity (r = 0.9263, t = 17.8251). Chloride has moderate positive correlation with E.C (r = 0.5299, t = 2.5827) also has weak positive correlation with turbidity (r = 0.1779, t = 5.5467).E.C has moderate positive correlation with TDS (r = 0.5393, t = 0.2354). Ph shows weak positive correlation with chloride (r = 0.2216, t = 5.4869) also for ph with TDS (r = 0.1901, t = 5.4421); for turbidity with TDS (r = 0.2056, t = 5.4706). The result of calculated correlation coefficient using equation further checked by MS Excel using CORREL function. Figure 2 represent strong positive correlation between alkalinity and turbidity. Regression equation also shows in the graph. R^2 (coefficient of determination) reveals that 86% in the variation of turbidity is due to variation of alkalinity.

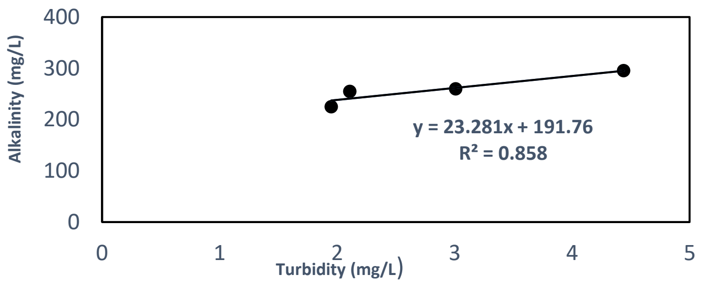


Fig. 2. Correlation between alkalinity and turbidity

Figure 3 represents strong negative correlation between alkalinity and p^h. Regression equation of ph also shows in this graph. The intercept (expected mean) value is 1065.6 and slope is -106.66. For any value of p^h the value of alkalinity can forecast.

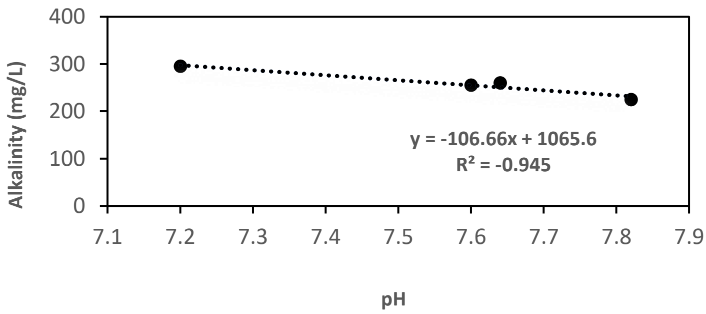


Fig. 3. Correlation between alkalinity and pH

Table 7. Results of WQI for location 1

Parameters	Concentration (mg/L) (Ci)	WHO (mg/L) (Si)	Weight (wi)	Relative weight (Wi)	Qi = (Ci/Si) *100	Sii = Wi*qi
Ph	7.2	6.5-8.5	4	0.117647	96	11.29412
E.C	1400	750	4	0.117647	186.66	21.96
TDS	860	500	4	0.117647	172	20.23529
Cl-	420	250	3	0.088235	168	14.82353
NO3-	0.2	10	5	0.147059	2	0.294118
Turbidity	4.44	4	3	0.088235	111	9.794118
Alkalinity	295	300	3	0.088235	98.33	8.676176
Mn	0.5	0.1	4	0.117647	500	58.82353
Fe	0.47	0.3	4	0.117647	156.66	18.43059
		Sum =	34		WQI =	164.3315

As the required WQI exceeds value of 100, so it is said that the water quality in this location is not suitable for drinking purposes and grating as E (Table 7).

The value of WQI was found 72.99 reveals in the ranges of 76 to 100, so the water quality is very poor for location 2 and grating as D. In addition, the value of WQI exceeding 100 (119.38) for location 3 and the water quality is not suitable for drinking purposes and the grating is as E. And finally, for location IV the value is 80.08 which is between the range of 76 to 100 that means water quality is very poor of this location and grating as D.

The graph below represents the spatial variation of WQI around Rajbandh dumping site. Low WQI value less than 50, represent good quality water. The yellow to green sign indicates the location of poor to very poor water quality, on the other hand, the blue to deep blue sign indicates lager WQI values unsuitable water quality for drinking purposes because it is location of landfill. So, graph mainly represents WQI reduces from landfill to surrounding locations because at landfill location groundwater quality somehow affect by solid waste.

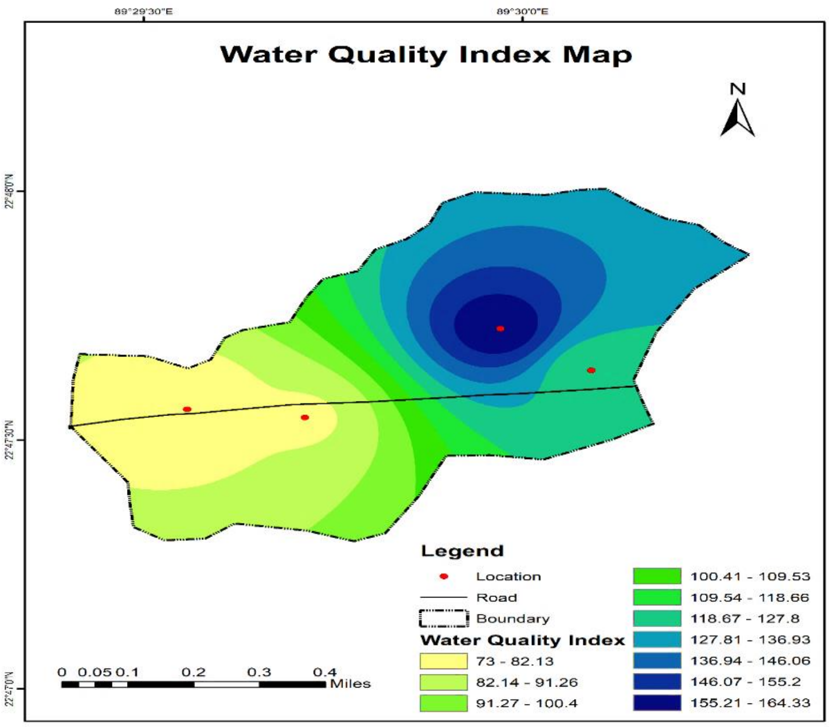


Fig. 4. Spatial variation of water quality index by ArcGIS

Table 8. Obtained value of water quality parameters for location 1

Water Quality parameters	Obtained value	Bangladesh standards	Comments
Ph	7.2	6.5- 8.5	Acceptable
Color (Pt- Co units)	16	15	Not acceptable
Turbidity (NTU)	4.44	10	Acceptable
Hardness (mg/L as caco3)	213	200-500	Acceptable
Alkalinity (mg/L)	295	200	Acceptable
Arsenic (mg/L)	Nil	0.05	Acceptable
Nitrate (mg/L)	0.2	10	Acceptable
Chloride (mg/L)	420	150-600	Acceptable
Iron (mg/L)	0.47	0.3-1	Acceptable
TDS (mg/L)	860	1000	Acceptable
BOD5 ppm	0.9	0.2	Not acceptable
COD ppm	16.78	4	Not acceptable
Conductivity (µs)	1400	-µs/cm	Not acceptable
Phosphate (mg/L)	0.54	6	Acceptable
Manganese (mg/L)	0.5	0.1	Not acceptable
FC (N/100ml)	45	Nil	Not acceptable
TC (N/ 100ml)	100	Nil	Not acceptable
Sulfate (mg/L)	0.00	400	Acceptable
Cu (mg/L)	0.1	1	Acceptable
Zn (mg/L)	0.1	5	Acceptable

From the obtained data it is noticed that the concentration of some parameters are exceeded the allowable limit and risk assessment process was done for those parameters according to USEPA guidelines. Table 8 represent CTE, non-carcinogenic condition for children

Table 9. Summary of Health risk assessment for physico- chemical, heavy metals and biological parameters in GW1 for Central Tendency Exposure condition (CTE), (non-carcinogenic condition)

Parameters	CDI (Child)		Rfding	Rfdderm	HQ (Child)		Total HQ
	Ingestion	Dermal			Ingestion	Dermal	
Alkalinity	22.042	0.504	200	200	0.110	2.52E-03	0.123
BOD	67.2E-03	1.54E-03	0.2	0.2	0.336	7.7E-03	0.344
Fe	35.12E-03	8.02E-04	9.00E-03	7.00E-01	3.902	1.15E-03	3.903
As	0.00	0.00	3.00E-04	1.23E-04	0.00	0.00	0.00
Chloride	31.382	0.717	250	250	0.126	2.68E-03	0.128
COD	1.254	0.028	4	4	0.322	7E-03	0.33
Mn	0.0374	8.53E-04	4.60E-02	1.84E-03	0.813	0.464	1.277
Cu	7.47E-03	1.71E-04	4.00E-02	1.20E-02	0.187	0.014	0.201
Zn	7.47E-03	1.02E-04	3.00E-01	6.00E-02	0.025	1.7E-03	0.027

The above sample calculations are done on Hogladanga landfill (location1) groundwater sample, because it is located in severe location. From the calculation it is said that, Fe and Mn cross the risk limit. BOD, COD are in moderate conditions and the rest of all are within limit. Rfd for ingestion and dermal in case of physico-chemical parameters and biological parameters are considered their allowable limit by converting mg/L unit to mg/kg/day unit. Then the water samples were collected from Joykhali landfill (location 2), Progati Secondary School, Hogladanga (location 3) and R.S.O Hasari and culture (location 4). Mainly heavy metals were tested on these samples, because final variability and uncertainty mainly done on heavy metals.

Table 10. Concentration of heavy metals and physico-chemical parameters in groundwater samples

Parameters	Locations		
	Joykhali landfill	Progati Secondary School, Hogladanga.	R.S.O Hasari and culture
As (mg/L)	Nil	Nil	Nil
Fe (mg/L)	0.23	0.32	0.09
Mn (mg/L)	0.10	0.10	0.00

Uncertainty analysis (using 1-D Monte Carlo Simulation)

For the uncertainty analysis by MCS some calculations were made on Fe, Mn and As because these are heavy metals and MCS mainly deals with heavy metals. Hazard quotient (HQ) and hazard index (HI) were calculated based on mean condition and are shown below.

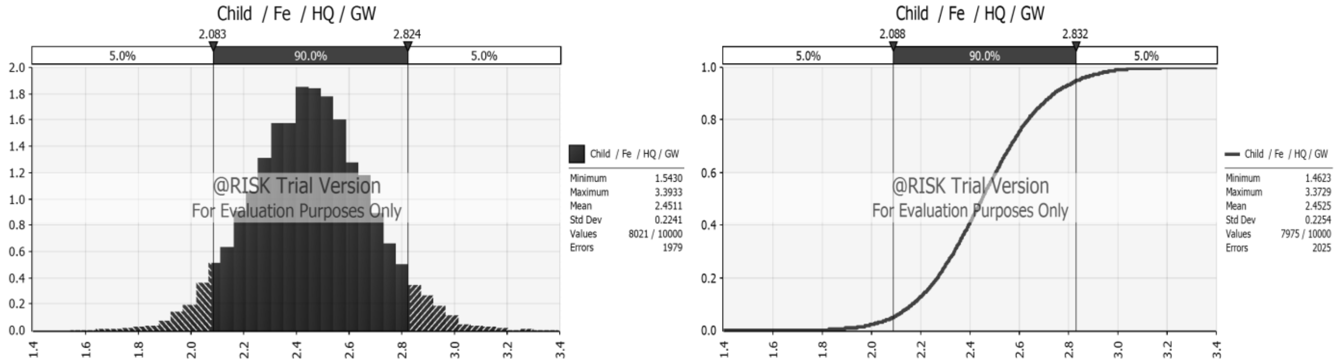
Table 11. Tabulated value of HQ and HI on heavy metals (Fe, Mn, As) for MCS operation

		Locations	Fe	Mn	As	HI
CHILD	**CTE**	GW1	0.47	0.5	0	
		GW2	0.23	0.1	0	
		GW3	0.32	0.1	0	
		GW4	0.09	0	0	
		Min	0.09	0	0	
		Max	0.47	0.5	0	
		Mean	0.2775	0.175	0	
	Ingestion	CDI (min)	6.72E-03	0.00E+00	0.00E+00	
		CDI (max)	3.51E-02	3.74E-02	0.00E+00	
		CDI (mean)	2.07E-02	1.31E-02	0.00E+00	
		HQ (min)	7.47E-01	0.00E+00	0.00E+00	
		HQ (max)	3.90E+00	8.12E-01	0.00E+00	
		HQ (mean)	2.30E+00	2.84E-01	0.00E+00	2.59E+00
	Dermal	CDI (min)	1.54E-04	0.00E+00	0.00E+00	
		CDI (max)	8.02E-04	8.53E-04	0.00E+00	
		CDI (mean)	4.74E-04	2.99E-04	0.00E+00	
		HQ (min)	2.19E-04	0.00E+00	0.00E+00	
		HQ (max)	1.15E-03	4.64E-01	0.00E+00	
		HQ (mean)	6.77E-04	1.62E-01	0.00E+00	1.83E-01
	HI		2.30E+00	4.47E-01	0.00E+00	

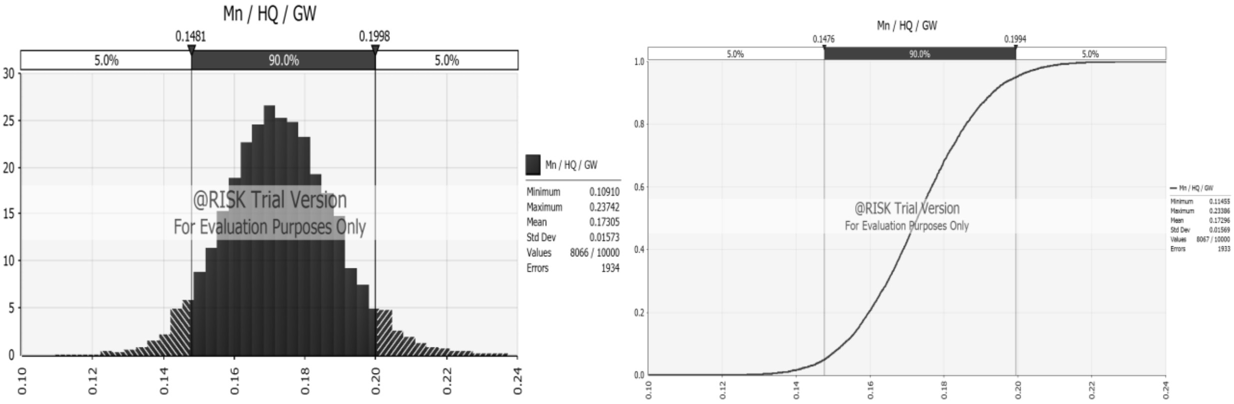
In MCS, discursive values are selected for each of the tasks, based on the range of estimates. The model is calculated based on these discursive values. The result of the model is recorded, and the operation is revolved. A typical MCS calculates the model hundreds or thousands of times, each time using several discursively- selected values. When the simulation is complete, a large number of results from the model are obtained, each based on discursive input values. These results are used to describe the expectancy or probability of reaching various results in the model. The analysis of uncertainty of exposure parameters and risk outputs were executed using 1-D MCS @Risk 7.5 with 10000 times iterations. In figure 5 the height of the bars (the y-axis) represents the relative frequency of Iron and Manganese and the spread of the bars (the x-axis) is the varying amounts of them.

The normal distribution of HQ for Fe and Mn in case of water ingestion and dermal contact is shown in Figure 5 with the values of minimum, maximum, mean and standard deviation. The total normal distribution is represented by both the PDF and

CDF which represented the summary of statistics, but are useful for conveying different information. From figure 5 both (a) and (b) 90% CI values indicating that after considering the uncertainties on the risk parameters of HQ for Fe and Mn in case of water ingestion and dermal contact it can be confidently said that the true HQ should lies between 2.083 to 2.824 and 0.1481 to 0.1998.



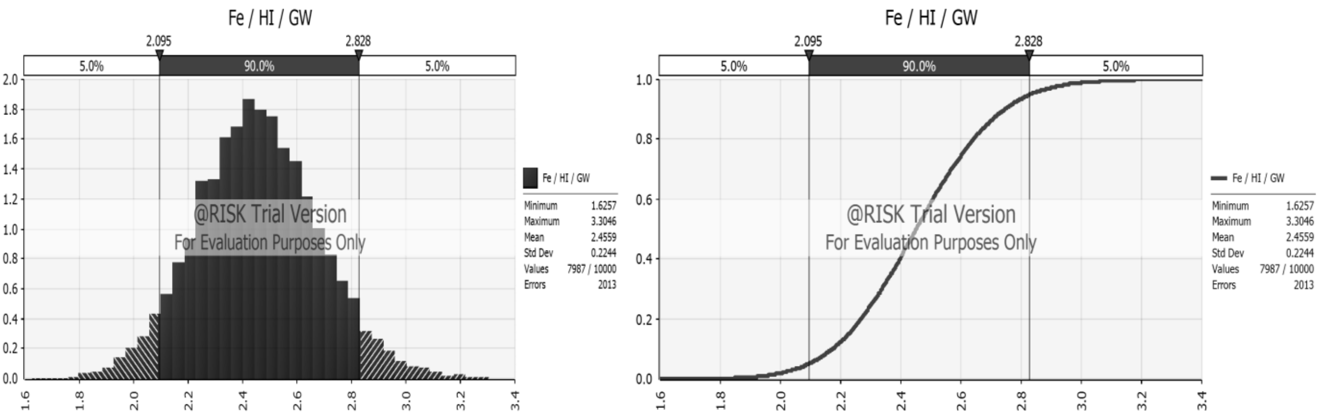
(a)



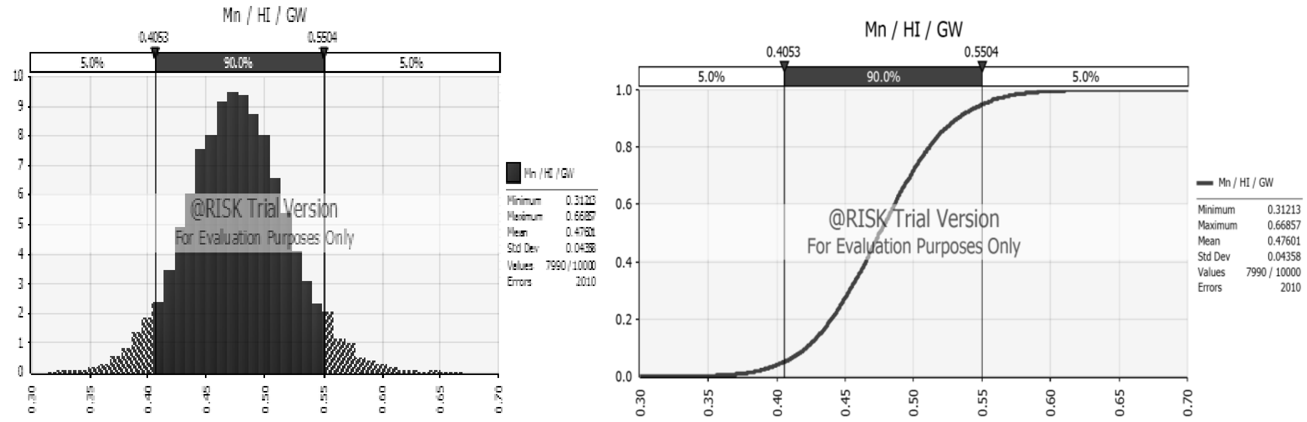
(b)

Fig. 5. Normal distribution of HQ of Fe and Mn of child for (a) ingestion (b) dermal for GW also Bell-shaped curve represents the PDF and S-shaped curve represents the CDF

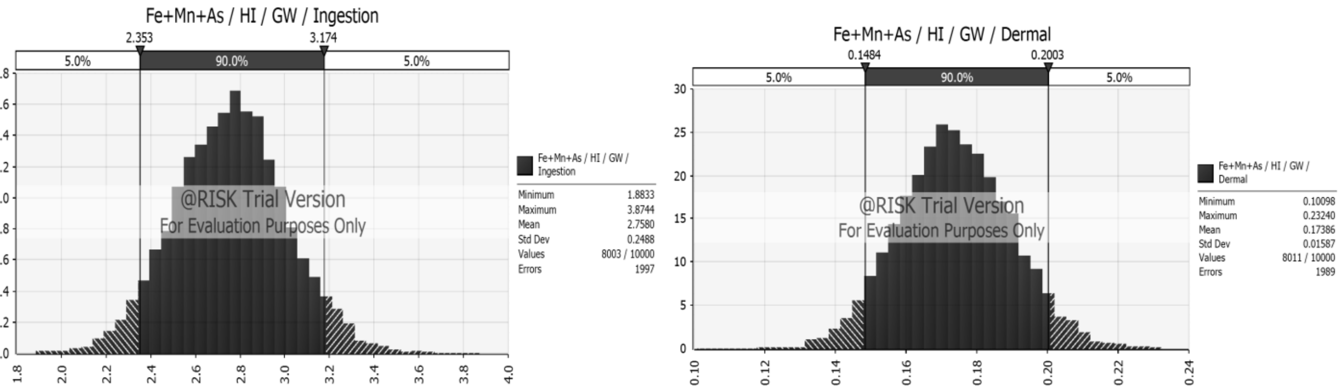
Hazard Index (HI) means the sum of the hqs for multiple substances or multiple exposures pathways from Environmental Terminology (2014) by Arizona Department of Environmental Quality. The hazard index cannot be translated to a probability that adverse effects will occur, and is not likely to be proportional to risk. Graphical representation of risk parameters (HI) are shown in figure 6.



(a)



(b)



(c)

Fig. 6. Normal distribution of HI of Fe and Mn of child for GW also Bell-shaped curve represents the PDF and S-shaped curve represents the CDF

5 CONCLUSIONS

A comprehensible negative correlation was found for ph with electrical conductivity (E.C), turbidity, alkalinity. A significant positive correlation was found for E.C with turbidity, alkalinity and for turbidity with alkalinity. The developed regression equations further can be used to find out the value of one parameter with respect to another if time is limited or budget is shorted. The test result reveals that 50% water samples were found poor quality and 50% water samples were found unsuitable for drinking purposes. Also, GIS based Graph showed WQI reduced from landfill to surrounding locations. For heavy metals results reveals that Fe and Mn have crossed the risk limit and the rest of all parameters are within limit. HQ value of Fe and Mn are greater than 1 for ingestion where the acceptable limit of HQ is 1 for non-carcinogenic health effect. The concentration of Arsenic (As) was nil for all locations. In case of HI the value of Fe is greater than 1 both CTE and RME conditions. Also, in case of pathway HI is greater than 1 for ingestion. So, result reveals that Fe and Mn can spread risk through water ingestion over a long period. So, it can be said that the groundwater quality of most of the locations were not suitable for drinking purposes or need to be treated. The results support the need for continuous monitoring of the groundwater

REFERENCES

[1] Jain, C., Bhatia, K and Vijoy, T. (1995). Ground water quality monitoring and evaluation in and around Kakinada Andhra Pradesh. Roorkee: National Institute of Hydrology.

[2] S. Mor, K. Rabindra, P. R. Dahiya and A. Chandra,. (s.d.). "Leachate Characterization and assessmwnt of groundwater pollution near municipal solid waste landfill site". Environmental Monitoring and Assessment, vol. 118, issue, 1-3, pp. 435-456, 2006.

[3] Ramakrishnaiah, C. R. And Ranganna, G. (2009). Assessment of Water Quality Index for the Groundwater in Tumkur Taluk. Karnataka State, India, 6 (2), pp. 523-530.

[4] Agarwal, A. And Saxena, M. (2011). Assessment of pollution by physicochemical Water Parameters Using Regression Analysis; A Case Study of Ganga River at Moradabad- India, 2 (2),. Pp. 185-189.

[5] R. Kaur and R. V. Singh. (s.d.). "Correlation Analysis of Groundwater Quality of Bichhwal Industrial Area, Bikaner". Chemical Environmental and Pharmaceutical Research, vol. 2, no. 2-3, pp. 146-151, 2011.

[6] Pangkaj, K. M and Islam, M. R. (2018). Risk-based assessment of heavy metal contaminated site at Khulna region of Bangladesh. (pp. 9-11). ICCESD.

[7] United States Environmental Protection Agency (USEPA). (1992). Central Tendency and RME Exposure Parameters.

[8] M. Biesiada. (s.d.). "Simulations in health risk assessment". Occupational Medicine and Environmental Health, vol. 14, no. 4, 397-402, 2001.

[9] D. M. Joshi, N. S. Bhandari and N. Agarwal. (s.d.). "Statistical Analysis of Physicochemical Parameters of water of River Haridwar District". Rasayan Journal, vol. 2, no. 3, 579-587, 2009.

[10] M. Tyagis, B. Sharma, P. Singh and R. Dobhal. (s.d.). "Water Quality Assessment in Terms of Water Quality Index". American Journal of Water Resources, vol. 1, no. 3, pp. 34-38, 2013.

[11] Kyame, N., Donkor, A., Boadu, T and Adimado, A. A. (2016). Evaluation of groundwater and surface water quality and human risk assessment for trace metals in human settlements around the Bosomtwe Crater Lake in Ghana. Springerplus, 5: 1812.

[12] F. B. Masok, P. L. Masiteng, R. D. Mavunda and P. P. Maleka. (s.d.). "An Integrated Health Risk Evaluation of Toxic Heavy Metals in Water from Richards Bay, South Africa". Environmental & Analytical Toxicology, vol. 7, no. 4. Pp. 1000487, 2017.