SSRG International Journal of Civil Engineering
ISSN: 2348 – 8352 /doi:10.14445/23488352/IJCE-V6I5P106

Volume 6 Issue 5, 30-43, May 2019

Risk Assessment and Health Risk Index Development of Municipal Solid Waste

Krishna Kumar Singh[1], Rakesh Chandra Vaishya[2]

[1]*Research Scholar, Department of Civil Engineering, Motilal Nehru National Institute of Technology Allahabad-Prayagraj, 211004, India.*

[2]*Professor, Department of Civil Engineering, Motilal Nehru National Institute of Technology Allahabad-Prayagraj, 211004, India.*

Abstract

Rapid urbanization leads to the generation of municipal solid waste, which creates problems for humans and the environment in the long run. Risks for a human being is one of the common deterioration of the environment, the assessment of environmental risk is very important at present. This paper presents the new concept of identifying risk assessment areas in municipal boundaries & health risk index developed from municipal solid waste. This study has been designed to evaluate the health risk index and determine the risk assessment areas from municipal solid waste in four municipal wards of the Allahabad city, India, using the Aggregation model and Multi-dimensional Comparative Analysis (MCA) Model.

The effects assessed were the possible impacts of solid waste on health and the environment. The resident's view regarding the location of the primary transfer of municipal solid waste was also taken. The data collection route was descriptive, analytical, and survey-based (questionnaires and field observations). The result shows that both residents & sweepers living near the primary transfer stations of municipal solid waste in the city were affected by skin diseases, eye irritation, Nausea & vomiting, malaria, chest pains, cholera, and diarrhea, etc. The final obtained ranking of sustainable development health risk indexes of solid waste of each municipal ward indicates that the 1st rank in high health risk area to the last rank in the lowest health-risk area.

Keywords - *Municipal solid waste, Risk Assessment, Health Impact, Aggregation model, MCA model, Allahabad Nagar Nigam.*

I. INTRODUCTION

Concern about public health, lack of resources, and aesthetics, as the main directors of municipal solid waste [16] to settled communities dates back to 10000 B.C. [27]. Small settled societies in the particular area buried solid wastes out of their residential environment [24]. Most human activities create waste, and these wastes are handled, stored, collected, and disposed of in open areas or open places, which can pose risks to the environment and public health [11].

Nowadays, the risk is addressed by a wide variety of special research fields and even by different scientific disciplines. Risks for the human being is one of the common deterioration of the environment; therefore, environmental risk assessment is very important at present [20]. Other high-risk groups include the population living close to a waste dump and those whose water supply has become contaminated, either due to waste dumping or leakage from landfill sites [9], [17]. The organic content fraction of Municipal Solid Waste is an important component, not only because it constitutes a sizable fraction of the solid waste stream but also because of its potentially adverse impact upon public health and environmental quality. A major adverse impact is due to its attraction of rodents and vector insects for which it provides food and shelter. Impact on environmental quality takes the form of foul odors, unsightliness, land, water, air, and noise pollution [3]. Risk assessments will help MSW to identify high, medium, and low-risk levels. Risk assessments will help municipalities prioritize preventive measures and provide information on the probability of harm arising and the severity of harm. Understanding solid waste combines assessments of probability and severity to produce an assessment of risk to aid the decision-making process [9].

Human health risk assessment (HHRA) evaluates potential adverse health effects on humans exposed to environmental hazards together with uncertainties [21]. Four major components are included in a risk assessment process (**a**) Hazard identification: identifies whether the contaminants present lead to adverse effects on human health; (**b**) Exposure assessment: estimates the intensity, frequency, and duration of exposure; (**c**) Dose-response assessment: determines the relationship between dose and the adverse effects based on animal experiments and epidemiological studies; and finally, (**d**) Risk characterization [7]. This four-step process describes the nature and magnitude of risk for each exposure pathway and derives the total risk.

A wide range of health problems, including respiratory symptoms, irritation of the skin, nose, eyes, gastrointestinal problems, psychological disorders, and allergies [26]. Solid waste disposal sites are found on the premises of the urban areas, turning into the various sources of contamination due to the incubation and proliferation of flies, mosquitoes, and rodents; that in turn are diseases transmitters that effect on population's health, which has its organic defenses in a formative and creative state [2], [11]. Environment and Health Impact risk Assessment of Municipal Solid Waste Management is intended to identify and predict the impact of these activities and suggest preventive measures as appropriate for the environment and people's health and well-being and interpret and communicate information about the impacts [1], [12].

Municipal workers & residential people live and work under extensive health risks, which are largely undocumented, and suffer severe exploitation and deprivation. Water supply, drinking and washing, and sanitation facilities are usually very poor at dump sites, requiring better Health and welfare facilities [8]. The present study indicates the risk areas and types of diseases and their effect on human health from municipal solid waste and health index development in each municipal locality. Municipal solid waste generates 1.5-2 kg/household/day in Allahabad Municipal Ward [19], [25].

II. STUDY AREA

Allahabad is one of the most important cities of Uttar Pradesh, India, situated at 25°28' N latitude, 81°54' E longitude, and around 202 km distance from the state capital Lucknow, India. The municipal control of Allahabad is under **Allahabad Nagar Nigam,** which covers 80 municipal wards. This study was conducted in four municipal wards namely i.e. Mumfordganj (25° 28' 37.6314"N, 81° 51' 15.9474"E), Rasulabad (25° 29' 55.3194"N, 81° 51' 28.62"E), Salori (25° 29' 3.444"N, 81° 52' 34.9674"E) &Govindpur (25° 29' 16.26"N, 81° 52' 27.588"E). In four municipal wards, develop a health risk index from municipal solid waste. In these wards, data was collected near the location where solid waste is dumped on open sites or at the primary transfer station [18], from the questionnaire and approx. A number of households near these waste sites were also completed. The study area is shown in (Fig. 1 and 2).

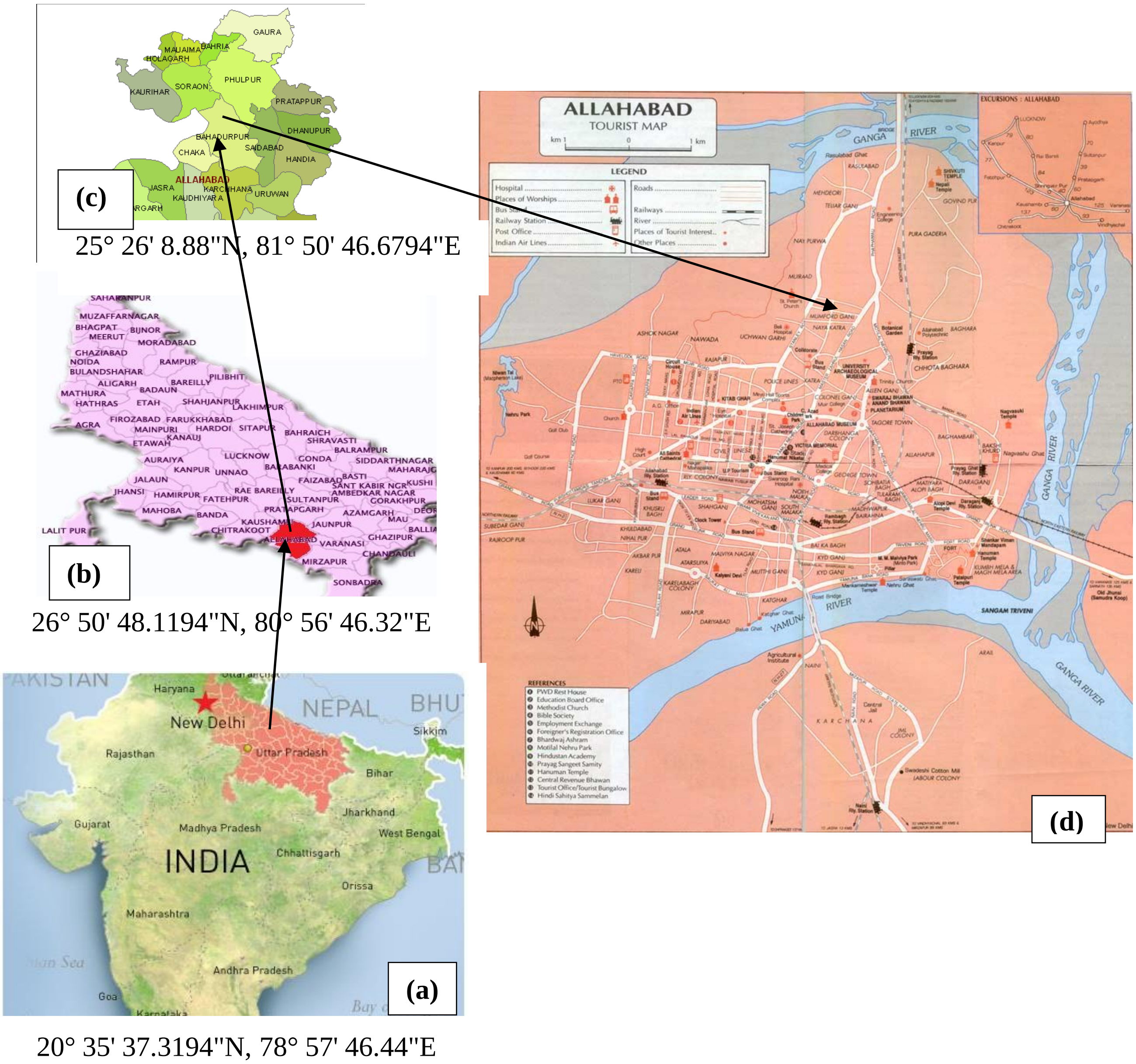

Fig. 1: Maps of (a) country (India), (b) State (Uttar Pradesh), (c) District (Allahabad), (d) Municipal Ward (Allahabad)
Source: Google

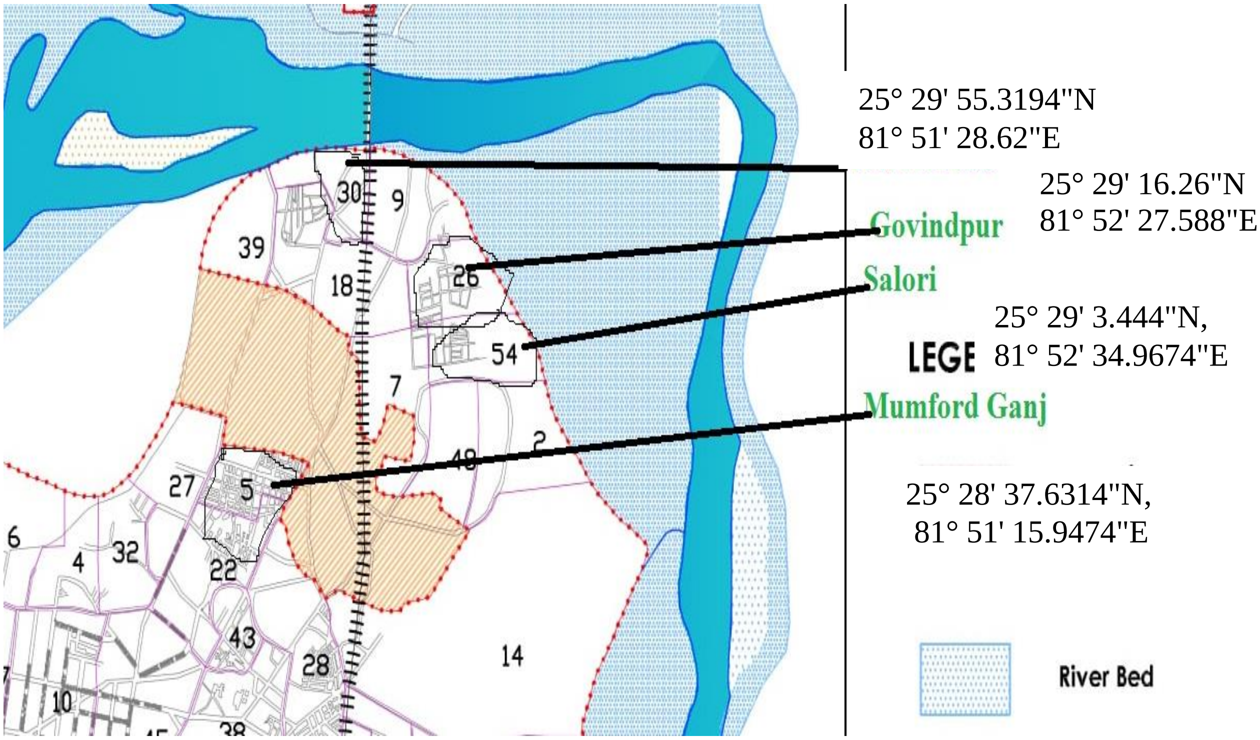

Fig. 2: Allahabad municipal ward map
Source: Allahabad nagarnigam

III. DATA COLLECTION

Data were collected in four phase: In the first phase of research the waste collection system was observed and then the locations were identified from where solid waste were being transferred known as primary transfer station or primary collection bins of municipal corporation as shown (Table 1).

TABLE 1
Selected Location of Municipal Wards

S.No.	Ward Name	No. of Location
1	Mumfordganj	12
2	Rasulabad	9
3	Salori	12
4	Govindpur	18

After no. of locations were chosen, then at each location number of households living near location where municipal solid waste open dumped or in primary transfer disposed. In second phase two types of questionnaires were developed (a)**-** Questionnaire based on residential people (b)**-** Questionnaire based on municipal workers and sweepers. From these questionnaires survey, type of health problems associated with waste dumping was enlisted.

In the third phase, local medical store and local doctor in the wards and hospitals nearby the wards were surveyed for determining the approximate number of diseases affected patients. Then summaries of all the type of health affected diseases, directly or indirectly from municipal solid waste, were providedwith weightage on average in 6 groups with 3 types of diseases in each group. The highly effected disease was given high weightage value of 6 and lowest to be 1.

In (Table 2, 3, 4 & 5) shown Solid waste generation in ward Mumfordganj, Rasulabad, Salori&Govindpur, selected location from (Table 1).

TABLE 2
Total Solid Waste Generation in Mumfordganj

S.N.	Mumfordganj Location	Latitude & Longitude	No. of Household	SWG(kg/day)
1	Location 1	N25˚28.646′, E81˚51.246′	45	90
2	Location 2	N25˚28.640′, E81˚51.240′	42	84
3	Location 3	N25˚28.693′, E81˚51.170′	48	96
4	Location 4	N25˚28.695′, E81˚51.158′	35	70
5	Location 5	N25˚28.701′, E81˚51.115′	53	106
6	Location 6	N25˚28.694′, E81˚51.114′	28	56
7	Location 7	N25˚28.695′, E81˚51.113′	32	64
8	Location 8	N25˚28.684′, E81˚51.161′	68	136
9	Location 9	N25˚28.605′, E81˚51.276′	55	110
10	Location 10	N25˚28.522′, E81˚51.488′	46	92
11	Location 11	N25˚28.597′, E81˚51.645′	25	50
12	Location 12	N25˚28.695′, E81˚51.113′	30	60

*SWG (solid waste generation)- approx. 2 kg/HH/day (source: HariBhari agency Allahabad)
*HH- Household

TABLE 3
Total Solid Waste Generation in Rasulabad

S.N.	Rasulabad Location	Latitude & Longitude	No. of Household	SWG(kg/day)
1	Location 1	N25˚29.910′, E81˚51.424′	48	96
2	Location 2	N25˚30.111′, E81˚51.319′	59	118
3	Location 3	N25˚30.108′, E81˚51.410′	42	84
4	Location 4	N25˚30.107′, E81˚51.411′	45	90
5	Location 5	N25˚30.135′, E81˚51.372′	38	76
6	Location 6	N25˚30.006′, E81˚51.387′	49	98
7	Location 7	N25˚29.973′, E81˚51.513′	52	104
8	Location 8	N25˚29.974′, E81˚51.515′	50	100
9	Location 9	N25˚29.942′, E81˚51.593′	58	116

SWG- (source: HariBhari agency Allahabad)
HH- Household

TABLE 4
Total Solid Waste Generation in Salori

S.N.	Salori Location	Latitude & Longitude	No. of Household	SWG(kg/day)
1	Location 1	N25˚29.040′, E81˚52.148′	65	130
2	Location 2	N25˚29.043′, E81˚52.147′	40	80
3	Location 3	N25˚29.036′, E81˚52.153′	38	76
4	Location 4	N25˚28.999′, E81˚52.267′	29	58
5	Location 5	N25˚28.997′, E81˚52.270′	30	60
6	Location 6	N25˚28.995′, E81˚52.272′	22	44
7	Location 7	N25˚28.972′, E81˚52.355′	45	90
8	Location 8	N25˚28.968′, E81˚52.379′	48	96
9	Location 9	N25˚29.035′, E81˚52.397′	37	74

10	Location 10	N25˚29.038′, E81˚52.146′	50	100
11	Location 11	N25˚29.032′, E81˚52.155′	42	84
12	Location 12	N25˚29.249′, E81˚52.473′	52	104

SWG- (source: HariBhari agency Allahabad), HH- Household

TABLE 5
Total Solid Waste Generation in Govindpur

S.N.	**Govindpur Location**	**Latitude & Longitude**	**No. of Household**	**SWG(kg/day)**
1	Location 1	N25˚29.181′, E81˚52.408′	40	80
2	Location 2	N25˚29.218′, E81˚52.394′	58	116
3	Location 3	N25˚29.228′, E81˚52.389′	46	92
4	Location 4	N25˚29.226′, E81˚52.391′	52	104
5	Location 5	N25˚29.352′, E81˚52.462′	41	82
6	Location 6	N25˚29.280′, E81˚52.551′	40	80
7	Location 7	N25˚29.330′, E81˚52.565′	44	88
8	Location 8	N25˚29.145′, E81˚52.580′	42	84
9	Location 9	N25˚29.147′, E81˚52.560′	45	90
10	Location 10	N25˚29.107′, E81˚52.580′	48	96
11	Location 11	N25˚29.051′, E81˚52.624′	58	116
12	Location 12	N25˚29.045′, E81˚52.625′	60	120
13	Location 13	N25˚28.965′, E81˚52.597′	64	128
14	Location 14	N25˚28.960′, E81˚52.596′	68	136
15	Location 15	N25˚29.690′, E81˚52.455′	58	116
16	Location 16	N25˚29.734′, E81˚52.213′	54	108
17	Location 17	N25˚30.033′, E81˚52.266′	66	132
18	Location 18	N25˚29.964′, E81˚52.234′	42	84

*SWG= Solid Waste Generation
SWG sources: HariBhari agency Allahabad, HH- Household

(Table 6) gives the type of diseases which effect on health from municipal solid waste based on questionnaire. Type of disease weight assign is 1-6; (1- very low, 2- low, 3-medium, 4- moderate, 5- High, 6- very High

TABLE 6
Type of Diseases Cause of Health Effect

Type of Diseases	**Weightage**
Skin diseases	**6**
Neurological diseases	
Flies breed	
Mosquito diseases	**5**
Lung diseases	
Congenital anomalies	
Malaria	**4**
Dengue	
Diarrhea	
Respiratory malfunction	**3**
Abnormality in breathing	
Blood infection	
Eye irritation	**2**
Nausea & vomiting	
Low birth weight	
Cancer	**1**
Congenital malfunction	
Heart problem	

IV. METHOD USED

Data has been obtained via questionnaire and field observation, the theoretical value of collected data was converted into numerical value using Aggregation model [23] (Table 7) followed by MCA (Multidimensional Comparative Analysis) model [5], [6]. These models were used to develop the risk assessment & health risk index arise from municipal solid waste. Aggregation model plays crucial role in calculation of environmental health risk index. Its affect the results quality in many ways because aggregation process is most of the simplifying process. Aggregation model consist of; additive form, multiplicative form and maximum or minimum operator. In present study, we have taken four models; three additive and one multiplicative. Maximum and minimum operators were excluded from present study because these types of operators are biased towards extreme.

TABLE7
Aggregation Model

S.N.	Aggregation Model	Formulation
Additive Form		
1	Root sum power addition (rspa)	rspa= HH*$(\sum_{i=1}^{n} S_i^4)$^$(\frac{1}{4})$
2	Root square addition (rsa)	rsa= HH*$\sqrt{(\sum_{i=1}^{n} S_i^2)}$
3	Root mean square addition (rmsa)	rmsa= HH*$\sqrt{\left(\sum_{i=1}^{n} \frac{1}{n} S_i^2\right)}$
Multiplicative Form		
4	Geometric mean (gm)	gm= HH*$(\prod_{i=1}^{n} S_i)$^(1/n)

*HH= No. of Household
*S_i= Diseases weightage, i= 1,2…..n; n= No. of diseases

After applying the aggregation model, MCA model has been applied in order to develop health risk index of the municipal solid waste and risk assessment of these area. The method allows the description of comprehensive phenomena, which were determined by more than one variable. The used Aggregation model was described with a set of m-diagnostic features. These features were usually determined as stimulants [14], [15]. Following steps were used to develop the index as follows:

Steps 1: Matrix X was formed from four aggregation models Eq. (4.a).

Set of matrix X;

X= X_{ij}; where, (i= 1,2,…n), i= no. of location

(j=1,2….m), j= no. of Aggregation model use

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}_{mxn} \quad \text{Eq. (4.a)}$$

Steps 2: The matrix X was then standardized into another matrix Z, Eq. (4.c). Set of attributes which are describing the individual objects should be unified through standardization according to the formula [13]:

$$Z_{ij} = \frac{X_{ij} - \overline{XJ}}{SD_j} \quad \text{Eq. (4.b)}$$

Where, $\overline{XJ}$= arithmetic mean of the j^th feature
SD_j=standard deviation of the j^th feature
X_{ij}= the initial value of the standardized Z^th Aggregation models value for i^th location
Z_{ij}= j^th standardized aggregation model value of X_{ij}.

$$Z = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1n} \\ z_{21} & z_{22} & \cdots & z_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots \\ z_{m1} & z_{m2} & \cdots & z_{mn} \end{bmatrix}_{mxn} \quad \text{. Eq. (4.c)}$$

Steps 3: Standardized values allow to determine the pattern, which could be defined as the best theoretical object H_0 characterized by the standardized variables [22].

H_0 =(Z_{01}, Z_{02},….,Z_{0n})

Where,Z_{01}, Z_{02},….,Z_{0n}; the minimum standardized aggregation model value of jth features.

Steps 4: Determine the Health Risk Index (HRI) Eq. (4.d) of municipal solid waste & access the risk area [10].

HRI = $\frac{D_{io}}{D_0}$; HRI= Health risk index Eq. (4.d)

Where, D_{i0}= Distance for ith location from the subject H_0.

D_0= model value of the distance

$$D_{i0} = \sqrt{\sum_{j=1}^{n}(Zij - Zoj)^2}$$

$$D_0 = \overline{D_0} + 2S_0 \quad ; \quad \overline{D}_0 = \sum_{i=1}^{m} D_{i0} / m$$

$$S_0 = \sqrt{\sum_{j=1}^{m}(Dio - \overline{D_0})^2}$$

Calculate HRI for each location.

V. RESULTS & DISCUSSIONS

The calculation of Health Risk Index of four Allahabad municipal ward has been represented on map with ranking is shown by (Fig. 4, 5, 6 & 7).Fig. 3 shows the preliminary analysis (Table 2) of solid waste generation of each ward and combined comparison of solid waste generation.

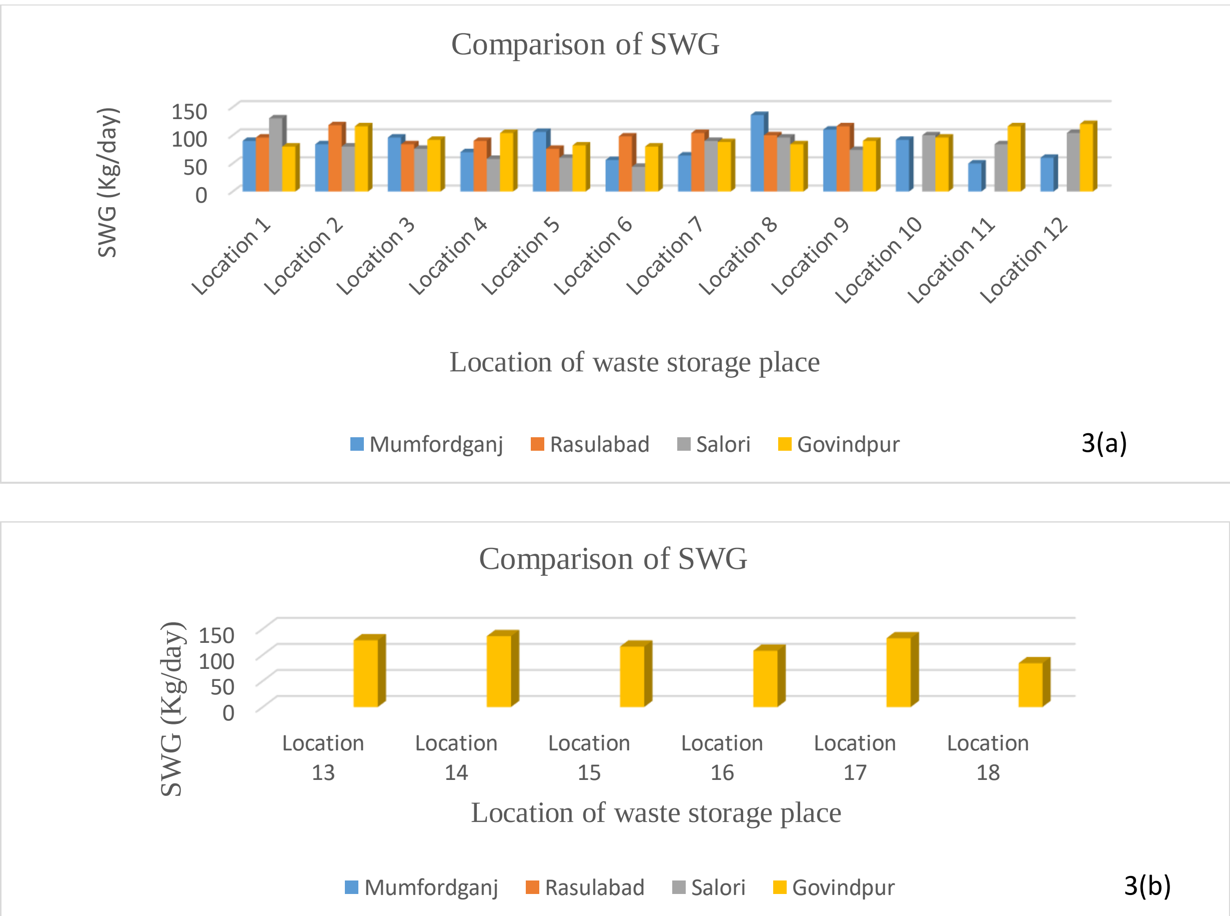

Fig. 3: (a)- Comparison of SWG in 12 location of 4 ward
(b)- Comparison of SWG in remaining 6 location

A. Finding Health Risk Area

HRI, HH and type of disease for Mumfordganj, Rasulabad, Salori&Govindpur wards has been calculated with the help of Aggregation model and MCA model, corresponding calculated values are shown in (Table 8, 9, 10 &11) and (Fig. 4, 5, 6 & 7). First rank of MCA model describe the location which does not any kind of bins and less solid waste management near to the resident.

TABLE 8
(a) Set a Matrix from Aggregation Model of Mumfordganj, (b) Using MCA Model Develop HRI

Mumfordganj			
X			
rspa	**rsa**	**rmsa**	**gm**
301.0083	376.497	217.3707	201.6632
281.5008	361.2977	180.6488	153.8393
328.4739	432.0000	216.0000	188.927
180.4136	204.0833	144.3087	135.5544
337.7389	427.2997	213.6498	183.5974
140.9424	153.3623	88.54377	60.32417
165.8763	197.2612	113.8888	99.43144
409.2535	430.0698	304.1052	235.5589
379.8464	524.6666	214.1942	164.6587
305.1689	370.8639	214.1183	180.0839
129.5908	154.1104	88.97565	77.68081
198.6367	236.2202	136.3818	93.21698

Mumfordganj		
Location	**HRI**	**Rank**
Location 1	0.8855459	**6**
Location 2	0.9974638	**1**
Location 3	0.9134055	**5**
Location 4	0.8673197	**8**
Location 5	0.9497054	**4**
Location 6	0.9520499	**3**
Location 7	0.7560841	**8**
Location 8	0.8745938	**7**
Location 9	0.9793635	**2**
Location 10	0.7201405	**11**
Location 11	0.7560841	**8**
Location 12	0.7106177	**12**

Fig. 4: Health Risk Area of Mumfordganj from MSW selected location show on map

TABLE 9
(a) Set a Matrix from Aggregation Model of Rasulabad, (b) Using MCA Model Develop HRI

Rasulabad			
X			
rspa	**rsa**	**rmsa**	**gm**
248.8144	295.8919	170.8333	149.1472
407.4716	562.8241	229.772	176.6339
281.5356	363.7307	162.6653	99.79943
310.7834	429.2726	175.2498	134.7208
262.4105	360.4997	161.2203	113.7642
246.5532	263.8731	186.5864	154.9516
348.5248	447.3209	223.6605	190.4678
305.5172	353.5534	176.7767	122.4745
354.3364	406.0000	234.4042	105.393

Rasulabad		
Location	**HRI**	**Rank**
Location 1	0.8905554	**6**
Location 2	0.9331347	**3**
Location 3	0.5991327	**9**
Location 4	0.9331347	**3**
Location 5	0.9715449	**1**
Location 6	0.9122032	**5**
Location 7	0.9445535	**2**
Location 8	0.7387072	**8**
Location 9	0.883911	**7**

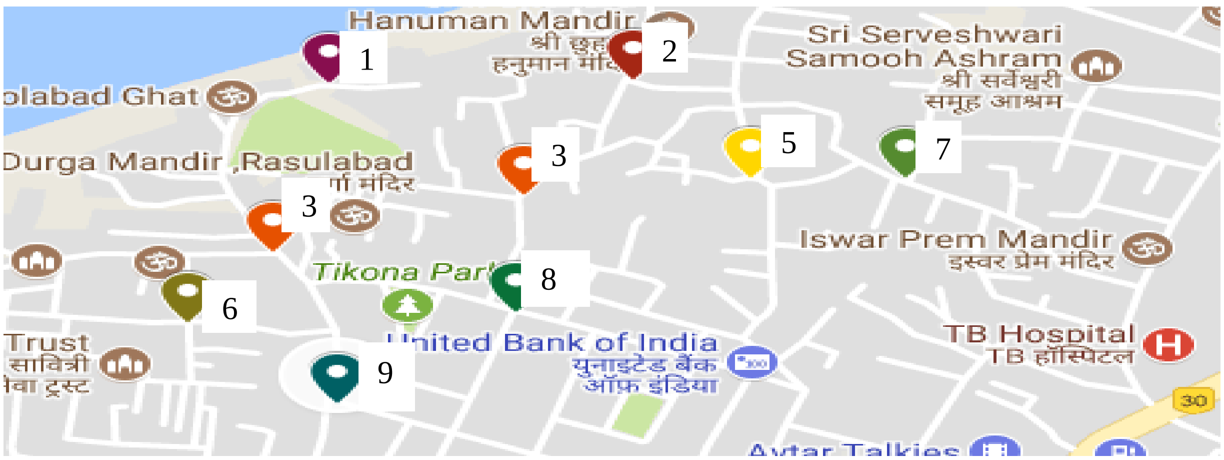

Fig. 5: Health Risk Area of Rasulabad from MSW selected location show on map

TABLE 10
(a) Set of Matrix from Aggregation Model of Salori, (b) Using MCA Model Develop HRI

Salori			
X			
rspa	**rsa**	**rmsa**	**gm**
448.8601	616.6441	275.7716	242.3148
254.9359	324.9615	145.3272	108.0768
212.5589	281.8155	126.0317	98.9965
150.3254	178.768	103.2118	90.10974
207.189	286.1818	116.8332	89.81385
151.9386	209.8666	85.67769	65.86349
141.223	162.2498	90.0000	90.0000
248.8144	295.8919	170.8333	149.1472
252.7355	324.6737	187.4504	182.4997

Salori		
Location	**HRI**	**Rank**
Location 1	0.7302007	**10**
Location 2	0.9875143	**2**
Location 3	0.7387822	**9**
Location 4	0.9144862	**5**
Location 5	0.7112406	**11**
Location 6	0.7112406	**11**
Location 7	0.8725044	**7**
Location 8	0.9144862	**5**
Location 9	0.9697807	**3**

272.4043	320.1562	226.3846	223.6068
280.9762	353.8983	176.9491	129.363
105.5882	116.2755	82.21922	73.53911

Location 10	0.9929574	**1**
Location 11	0.9324867	**4**
Location 12	0.8426371	**8**

Fig. 6: Health Risk Area of Salori from MSW selected location show on map

TABLE 11
(a) Set a Matrix from Aggregation Model of Govindpur, (b) Using MCA Model Develop HRI

Govindpur			
X			
rspa	**rsa**	**rmsa**	**gm**
276.2519	381.5757	155.7776	119.7518
400.5653	553.2847	225.8775	173.6401
308.3486	398.3717	178.1572	129.9608
269.5489	320.5495	185.0694	161.5761
261.2697	330.5526	165.2763	142.0282
125.5316	144.2221	101.9804	97.97959
264.8111	278.2804	196.774	152.4205
278.6325	338.6148	195.4994	164.4244
91.37444	100.6231	71.15125	63.63961
241.6156	262.9068	151.7893	103.4129
388.7873	502.2947	224.633	163.8636
414.3779	572.3635	233.6664	179.6277
442.0031	610.5211	249.2442	191.6029
469.6283	648.6787	264.822	203.5781
182.0208	209.122	116.000	116.0000
169.4676	194.6998	137.6735	132.2724
397.2166	417.4207	295.161	228.6307
278.0553	328.0305	231.9526	230.0435

Govindpur		
Location	**HRI**	**Rank**
Location 1	0.8277687	**8**
Location 2	0.8277687	**8**
Location 3	0.7017667	**17**
Location 4	0.7470423	**15**
Location 5	0.8015125	**13**
Location 6	0.9647368	**1**
Location 7	0.8384375	**6**
Location 8	0.7046881	**16**
Location 9	0.7929148	**14**
Location 10	0.8911325	**3**
Location 11	0.7017667	**17**
Location 12	0.8277687	**8**
Location 13	0.8277687	**8**
Location 14	0.8277687	**8**
Location 15	0.8872339	**4**
Location 16	0.9647368	**1**
Location 17	0.8384375	**6**
Location 18	0.8497907	**5**

Fig. 7: Health Risk Area of Govindpur of MSW selected location show on map

Places in which sewage water are mixed in solid waste comes under the maximum risk zone and set to first rank. Places in which bins and solid waste are properly managed is called lowest risk zone and set to last rank. Places in which bins are being used but there is no periodic cleaning operation is performed is called moderate risk zone and set to moderate rank. According to calculated value Mumfordganj was the high risk area and Salori was the lowest risk area. Latitude and longitude are marked in Fig. 4, 5, 6 & 7 shown over Google map of risk areas of wards Mumfordganj, Rasulabad, Salori&Govindpur respectively.

VI. CONCLUSION & SUGGESTION

The focus of the study was to develop the health index for each ward and selection of location where solid waste dump in open place or on road side or in bins. Current system of municipal solid waste disposal is very inappropriate; therefore, environmental studies is necessary in order to find novel and optimized techniques. All waste should be collected in proper bins and not to be thrown on road side or open place. Solid waste thrown in open sites do not make a way to water streams or in sewers. The study indicates the locations with high risk zone as shown in (Fig. 8) with help from develop health index. Primary transfer station should be properly located and managed to minimize its effects on the health & environment. The government and municipalities should revise laws regarding the locations of transfer station. These laws should include proper management of the waste collection station, which are well fenced in and away from human settlements. The government should annex laws which see to it that waste should be thrown only at primary transfer station or near bins provided by municipality or other collection agency properly and if it is not then action should be taken according to the law. There should be a follow up in the functioning to avoid pollution on the environment and health effected hazard waste.

Thus, index analysis using MCA model, is an effective tool for analyzing problems and it will provide new insights (environmental, economic, social and practical) for sustainable planning of municipal solid waste management system. Government and related authority can easily and clearly understand the details and the level of risk of the object.

Fig. 8: (a) Mumfordganj, (b) Rasulabad, (c) Salori, (d) Govindpur, (e) Govindpur
These location was in High Health Risk zone from develop health index in Table 8, 9, 10, 11.

REFERENCES

[1] Al-Khatib IA and Sato C,. Solid health care waste management status at health care centers in the West Bank. Palestinian Territory. Waste Management. 29, (2009),2398–2403.

[2] Antonopoulos, I. S., Perkoulidis, G., Logothetis, D., Karkanias, C., Ranking municipal solid waste treatment alternatives considering sustainability criteria using the analytical hierarchical process tool. Resources, Conservation and Recycling, 86, (2014), 149-159.

[3] Ayomoh, M.K.O.; Oke, S.A.; Adedeji, W.O.; Charles-Owaba, O.E,. An approach to tackling the environmental and health impacts of municipal solid waste disposal in developing countries. J. Environ. Manag, 88,(2008),108–114.

[4] Central Pollution Control Board (CPCB), Management of Municipal Solid Waste. Ministry of Environment and Forests, New Delhi, India.

[5] Cheng, S., Chan, C. W., Huang, G. H.,. An integrated multi-criteria decision analysis and inexact mixed integer linear programming approach for solid waste management. Engineering Applications of Artificial Intelligence,16(5), (2003), 543-554.

[6] Chatterjee A., Mukherjee S. and Kar S., Poverty Level of Households. A Multi-dimensional Approach Based on Fuzzy Mathematics Fuzzy Information and Engineering **6,**(2014), 463-487.

[7] D. Wawrzyniak,. Standard Of Living In The European Union, Comparative Economic Research, 19(1),(2016),141-155.

[8] Daniel, H., What a waste, solid waste management in Asia. Washington DC., (1999).

[9] Defra,. Review of environmental and health effects of waste management: Municipal solid waste and other similar wastes., (2004).

[10] Distaso A., Local sustainable development and well-being/quality of life. An application of the capability approach at regional level Quaderno 25,(23-26).

[11] Frazzoli, C.; Orisakwe, O.E.; Dragone, R.; Mantovani, A,. Diagnostic health risk assessment of electronic waste on the general population in developing countries' scenarios. Environ. Impact Assess. Rev.30,388–399.

[12] Giusti, L,. A review of waste management practices and their impact on human health. Waste Manag., 29,(2009),2227–2239.

[13] Jain A. and Ganti S.,. A taxonomy for evaluation and comparison of financial performance of Indian IT companies Adarsh Journal of Management Research 8, (2015),1-13.

[14] K. Kompa, D. Witkowska,Comparison of European stock exchanges one-and multi-dimensional analysis, Indian Journal of Fundamental and Applied Life Sciences,4(S1), (2014),2111-2126.

[15] Kompa K. and Witkowska D., Synthetic measures of the European capital markets development Ekonometria. Econometrics 4,(2015), 216-22.

[16] Louis, G. E., A historical context of municipal solid waste management in the United States. Waste management & research, 22(4),(2004),306-322.

[17] Marshal, E., Analytic study to evaluate associations between dumpsites and birth effects. ATSDR CO.LTD: Atlanta., (1995).

[18] Mohammad S, Huda ATM, Hoque R., Household solid waste characteristics and management in Chittagong, Bangladesh. Waste Manage 28, (2007), 1688–1695.

[19] MufeedSharholy,Kafeel Ahmad, R.C.Vaishya, R.D.Gupta,. Municipal solid waste characteristics and management in Allahabad, India. Waste Management., 27(4),(2007),490-496.

[20] Nor, Z. Md., Kecojevic, V., Komljenovic, D., Groves, W., Risk assessment for loader- and dozer-related fatal incidents in U.S. mining, International Journal of Injury Control and Safety Promotion., 15,(2008),65–75.

[21] National Research Council (NRC), Risk assessment in Federal Government: Managing the process. National Academic Press, Washington, D.C., (1983).

[22] Pomianek I., Socio-economic development of agricultural problem areas in Poland Economics & Sociology.,**7,** (2014), 218-235.

[23] Sadiq R, Haji SA, Cool GV, Rodriguez MJ,. Using penalty functions to evaluate aggregation models for environmental indices. J Environ Manage, 91(3),(2010),706–716.

[24] Seadon, J. K., Integrated waste management–Looking beyond the solid waste horizon. Waste management, 26(12), (2006),1327-1336.

[25] Sharholy, M., Ahmad, K., Vaishya, R.C., Gupta, R.D., Journal of Waste Management 27(4), (2007),490–496.

[26] UNEP,. Environmental risk assessment for sustainable cities. IETC Technical Publication Series,. UNEP International Environmental Technology Center, Osaka/Shiga.,3,(1996).

[27] Worrell, W., Vesilind, P.,Solid Waste Engineering, SI Version. Cengage Learning. (2012).

[28] G. Akhilesh ready, M.Suren Rao, Municipal Solid Waste Composition and Recycle Process, SSRG International Journal of Geoinformatics and Geological Science 3(3) (2016) 32-35.