International Journal of Scientific Reports
Byamba-Ochir M et al. Int J Sci Rep. 2019 Aug;5(8):190-200
http://www.sci-rep.com
pISSN 2454-2156 | eISSN 2454-2164

DOI: http://dx.doi.org/10.18203/issn.2454-2156.IntJSciRep20193164

Original Research Article

Microbiological contamination and content of heavy metals in unlined landfill sites of Ulaanbaatar

Minjmaa Byamba-Ochir*, Oyunchimeg Tugjjav

Department of Ecology, School of Agroecology, Mongolian University of Life Science, Ulaanbaatar, Mongolia

Received: 27 June 2019
Revised: 11 July 2019
Accepted: 12 July 2019

***Correspondence:**
Minjmaa Byamba-Ochir,
E-mail: bsminjmaa@gmail.com

ABSTRACT

Background: The aim of the study was to investigate bacterial and heavy metal pollution in four landfill sites of Ulaanbaatar. Surveyed landfills included closed and currently operating unlined landfills.
Methods: In order to sample, we divided each landfill sites into three zones including zone 1: cover soil or in the boundary of the landfill, zone 2: from the boundary of the landfill to hygiene zone (25 $м^2$ to 500 $м^2$ out of cover soil), zone 3: from hygiene zone to settlement areas and compared the pollution.
Results: The titre of *Cl. perfringens*, presence of *Salmonella* and total bacteria were not significantly different for landfill sites. The titre of *E. coli and* the titre of *Proteus* for industrial landfill site were significantly different than other sites. The titre of *E. coli* and the titre of *Proteus* for the zone 1 were significantly different than the zone 3. The presence of *Salmonella* and the total bacteria for the zone 1 was significantly different than the zone 2 and zone 3. The titre of *Cl. perfringens* was not significantly different for landfill zones. The bacterial indicators were not significantly different for seasons of the year. Content of heavy metals in soil landfills were Pb 0.1-63 mg/kg, Cr 0.4-5124 mg/kg, Ni 3.2-84 mg/kg, Zn 21.7-776 mg/kg, Cd 0.01-2.8 mg/kg.
Conclusions: Microbiological contamination and content of heavy metals in closed unlined landfill are not different from currently operating unlined landfills.

Keywords: Municipal solid waste, Waste disposal, Soil pollution, Waste management

INTRODUCTION

The most common ways to manage such waste disposal are landfills and incinerators. Up to 95% total municipal solid waste collected is disposed of in landfills worldwide.[1-3] Currently, there is not any incinerator in Mongolia and wastes are disposed in unlined landfills.

Landfills in developing countries pose serious environmental and public health hazards. Developing countries challenges in solid waste management such as insufficient waste recycling, hazardous wastes that are not separated for safe disposal, and landfills that are not properly engineered to prevent groundwater pollution.[4]

In total, there are 391 landfill sites occupy 4543 hectares of land in Mongolia and 2102721 tonnes of waste has been disposed in 2016. Among the wastes disposed in landfill sites, the majority 49% were ger district, 24% were from business entities, 16% came from apartments, 5% from roads and 6% for others.[5] That year, 988390 tonnes of municipal solid waste was received in Ulaanbaatar city landfills including Narangiin Enger (NE), Morin Davaa (MD) and Tsagaan Davaa (TsD).

UCh landfill has been receiving municipal waste of city since 1977. It is unlined landfill which was closed in 2009.

NE landfill which was planned to be used for 20 years was built with investment of Japan International Cooperation Agency and commissioned in 2009. It also is unlined landfill and located in Songinokhairkhan district. It receives 1176 tonnes of waste or more than other landfill sites every day.

MD landfill which was planned to be used until 2020 became officially a landfill site in 2007. This landfill also is unlined. MD is located in Khan-Uul district where the various type of factories such as leather industry, which dispose their wastes to this landfill, are located. 449 tonnes of waste is disposed here daily.

TsD landfill which was planned to be used for 20 years was commissioned in 2012. The landfill is in Baynzurkh district and receives 1083 tonnes of waste every day.

Surveyed landfills are not built with liner system and do not uses even daily cover materials. There is lack of gas and leachate collection system in these landfills. Approximately 1-3 months after receipt of the waste, landfill cover operation is made with soil that brought from near the landfills. During the absence of cover, soil pollution can pose a risk to environment.

Unlimited and uncontrolled emissions of various substances into soil inhibit the development of soil bacteria. As a result, it causes a decrease in their count and enzymatic activity, which disturbs the soil environment homeostasis.[6] Uncollected solid waste also increases risk of injury, and infection. In particular, organic domestic waste poses a serious threat, since they ferment, creating conditions favourable to the survival and growth of microbial pathogens.[7]

UCh, NE and TsD landfills in UB have been causing several environmental problems including smells and smoke of open burnings, estrays and flies. Waste collection vehicles have negative impacts on living condition of residents, who live nearly to these landfills, including noise and dusts created by lost garbage.[8]

High-risk group includes 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.[7] The pollutants migrate vertically rather than laterally.[9] The microbial loads of air in the vicinity of various dumpsites in Delta State, Nigeria were all the tested parameters decreased with distance away from the dumpsites and the microbial loads were higher than regulatory limits. Therefore, recommended that dumpsites be located at a minimum 1 km distance away from residential quarters.[10] The pollution not only prevails around its vicinity during its period of operation but may linger on for a long time after the landfill or dump site ceased operations.[11] Solid wastes are sources of environmental pollution through introduction of chemical substances above their threshold limit into the environment.[12,13] Positive impacts of the dumped municipal wastes on the microbial and organic properties of the analyzed soils.[13]

According to the Order No. 404 “Procedure for activities of individuals, business entities and organisations to landfill and requirements for waste disposal and destruction, dedicated facility, landfill type” approved by Mongolian Minister of Nature and Environment in 2006, it is noticed that landfill should be located at about 500 m away from residential area to prohibit the population from conducting production or service or residing in the area.[14] However, this restriction zone was not mentioned in “Law of Mongolia on household and industrial waste” adopted in 2003 and “Law on waste” which adopted in 2012 as well. As stated in “Law on waste” which updated in 2017, centralised landfill protection zone is not less than 300 meters from apartment and public zone.[15] By this time, distance from the landfill to the settlement area is approximately 0.2-0.88 km.

Landfill sites in Ulaanbaatar do not monitoring on soil, water and air regularly. Therefore, the problem is lack of accurate information on the effects of unlined landfill sites on environment.

The purpose of this study was to investigate the bacterial pollution of soil and heavy metal concentration of soil in NE, MD and TsD and closed landfill site UCh. The main feature of this study is comparison made between activity and closed landfills, and characterisation of three zones that made from cover soil to settlement areas. The relevance of our research is to create pollution data of landfill sites in Ulaanbaatar for the first time to investigate soil pollution of landfill sites.

METHODS

Study area

We divided each landfill sites into three zones including zone 1: cover soil (both of active and non-active waste cell) or in the boundary of the landfill, zone 2: from the boundary of the landfill to hygiene zone (25 $м^2$ to 500 $м^2$ out of cover soil), zone 3: from hygiene zone to settlement areas and compared the pollution. Sample points are shown in the picture (Figure 1).

Sampling

Relating to the procedure mentioned above, we had collected surface soil pollution samples every quarter and heavy metal pollution samples from the landfills in every spring and autumn for two years.

Firstly, we built quadrats with side 5 metre and created diagonals. Then taken samples from 5 crossing points were placed into one sterile glass jars. The average weight of one sample was 500 g and samples were collected from 10 cm deep.[16] Sample of soil bacterial pollution should be taken in sanitary condition and taken to the sterilised bottle and sent to the laboratory for analysis within 24 hours after creating the appropriate address.[17]

Order No.404 also noticed that "Relating to the program approved by the Governor of Province and Capital, Environmental Office should conduct environmental analysis in a specially designated site once a half year and bacterial analysis at least once a quarter".[14]

This is the reason we collected pollution samples once in a quarter, control samples of bacterial pollution from non-urban settlement area (in control soil out of urban)**.** While heavy metal pollution sample is collected twice a year (Spring and Fall). Control samples of heavy metal pollution (control UCh, control NE, control MD, control TsD) from were collected from clean places near landfill sites. We also took sample from clean area where bacterial control samples taken to compare with mean of heavy metal concentration samples of landfill sites and Table 4 involve this comparison.

Total of 139 samples (92 samples for bacterial contamination and 47 samples for heavy metals) were taken from 4 landfills.

Laboratory and statistical analysis

Soil temperature during sampling bacterial pollution was measured by digital thermometer with probe sensor TP3001.

As stated in gravimetric method, we used soil sample that has been dried to constant weight in oven at temperature between 105 ^{o}C and determined the evaporated water weight to measured the soil sample mass.[18]

The soil pH was measured in water (1:2.5 H_2O) with electronic pH meter and a glass electrode. 10 gram of air-dried soil sample was taken in a 50 ml beaker and 25 ml of distilled water was added to it. The suspension was stirred for 20 to 30 minutes using magnetic stirrer. Then a digital pH meter was used to measure the pH of solution after 1 h of standing for sedimentation.[19]

According to Mongolian norms for soil sanitation assessment in urban settlements, sanitary condition is assessed with the titre of *Escherichia coli*, the titre of *Clostridium perfringens.*[20] Hence, we studied these bacterial indicators including titre of *Escherichia coli (E. coli)*, the titre of *Proteus*, the titre of *Clostridium perfringens (Cl. perfringens)*, the presence of *Salmonella* and total bacteria.

The microbiological tests were determined the following:

- The titre of *E. coli* was determined by membrane filtration method using Endo Agar medium.[21]
- The titre of *Proteus* was determined by meat peptone agar.[22]
- The titre of *Cl. perfringens* was determined by membrane filtration method using Clostridial perfringens agar.[23]
- Buffered peptone water pre-enrichment medium, Selenite Broth enrichment media and bismuth sulfite agar by selective isolation were used for the presence of *Salmonella* respectively.[24]
- Total bacteria were enumerated by viable plate count technique; for this, 10 g of soil sample was taken into 90 ml of sterile distilled water and mixed well for 2 minutes. The soil suspension was subjected to tenfold serial dilutions were made 10^{-1}-10^{-7} and 100 µl of diluted cells were spread on agar medium nutrient agar and plate count agar were used.[25]

This laboratory analysis of soil was made along the standard method of the Mongolian Institute of Public Health. Content of heavy metals were determined using atomic absorption spectrophotometer in Central Geological Laboratory of Mongolia.

Statistical analysis of data was performed using Sigma plot 14 software. Significant differences in the effect of the landfill sites, zones and the seasons on bacterial indicators in soil were tested using one way analysis of variance. Tukey's test was used to determine which bacteria are statistically different. Furthermore, a comparison between the effect of heavy metals for landfill sites and zones was conducted with a one-way ANOVA.

RESULTS

The potential of hydrogen (pH), moisture and temperature of soil during sampling of soil bacteria are shown in Table 1. These measurements are taken from every sample of bacterial pollution and the sampling dates are as same as the date of bacterial pollution samples (Date of sampling in Table 2). We also made a comparison between soil bacterial samples of pollution of landfill sites and samples taken from outside the city where the settlement area is unaffected. The mean of pH of the soil ranged between 6.92 and 7.58, moisture varied from 3.89% to 13.78, and temperature was between 5.71 ^{0}C and 9.75 ^{0}C (Table 1).

Table 2 indicates that determination of the titre of *E. coli*, the titre of *Proteus*, the titre of *Cl. perfringens*, the presence of *Salmonella* and total bacteria from landfills soil. In cover soil of landfill, the total bacteria count ranged from 0.1×10^6 CFU/g to 460×10^6 CFU/g while the total bacteria count ranged from 0.014×10^6 CFU/g to 0.3×10^6 CFU/g in control soil out of urban. The titre of *E. coli*, the titre of *Proteus*, the titre of *Cl. perfringens*, the presence of *Salmonella* were not detected in the control soil out of urban area.

Table 3 indicates content of heavy metals such as lead, chromium, nickel, zinc and cadmium. Concentration of Pb, Ni, Zn and Cd did not exceed the norm of Mongolia but higher than the content of net soil out of urban area. We detected that Cr concentration in NE2.4, NE3.4, MD1.2, MD2.4 and Zn concentration in NE2.4 were more than the precaution value. According to our analysis, the mean concentrations of heavy metals in landfill sites are higher than control out of urban.

Table 1: Potential of hydrogen, moisture, temperature of soil of landfill sites.

Landfill sites	Zone	pH	Moisture,%	T [^{0}C]
UCh	Zone 1	7.27±0.44	9.05±3.26	9.34±15.46
	Zone 2	7.58±0.22	3.89±1.06	9.63±14.81
	Zone 3	7.45±0.31	4.66±1.85	8.75±15.54
NE	Zone 1	7.49±0.18	6.59±1.03	8.7±16.56
	Zone 2	6.92±0.85	11.63±11.25	8.33±16.62
	Zone 3	7.28±0.45	5.63±2.01	8.15±16.87
MD	Zone 1	7.52±0.26	13.78±13.10	6.75±16.52
	Zone 2	7.54±0.20	5.1±2.53	8.63±17.11
	Zone 3	7.5±0.11	4.26±2.10	9.75±18.75
TsD	Zone 1	7.52±0.19	11.59±4.24	6.33±15.52
	Zone 2	7.38±0.46	9.79±4.59	8.75±18.50
	Zone 3	7.11±0.51	10.09±3.90	9.06±18.31
Control		7.19±0.34	3.92±1.89	5.71±14.92

Table 2: Bacterial contamination in soil of landfill sites in UB.

Sampled points	Sample number	Date of sampling	*E. coli*	*Proteus*	*Cl. prefringens*	*Salmonella*	Total bacteria, CFU/g×10^6
UCh1.1	S1	22/02/2016	0.001	0.001	0	0	0.44
	S2	20/02/2017	0.1	0.1	0.1	1	5.2
UCh2.1	S1	22/02/2016	0.001	0.001	0	0	3.1
	S2	20/02/2017	0.01	0.01	0	0	1.9
UCh3.1	S1	22/02/2016	0.001	0.001	0	0	0.28
	S2	20/02/2017	0	0.1	0	0	3
UCh1.2	S1	11/05/2016	0.01	0.01	0	0	5.2
	S2	17/05/2017	0.001	0.001	0	0	14.8
UCh2.2	S1	11/05/2016	0.1	0.1	0	0	4.1
	S2	17/05/2017	0.01	0.01	0	0	9.5
UCh3.2	S1	11/05/2016	0.01	0.01	0.1	1	189
	S2	17/05/2017	0.1	0.1	0	1	7.6
UCh1.3	S1	25/07/2016	0.0001	0.0001	0.001	1	87
	S2	05/07/2017	0.001	0.001	0	0	14.1
UCh2.3	S1	25/07/2016	0.01	0.01	0.01	1	3.5
	S2	05/07/2017	0.01	0.01	0	0	3.5
UCh3.3	S1	25/07/2016	0	0.1	0	0	2.6
	S2	05/07/2017	0.1	0.1	0	0	2.7
UCh1.4	S1	20/10/2016	0.001	0.001	0.01	1	6.8
	S2	18/09/2017	0.001	0.001	0.1	1	15.5
UCh2.4	S1	20/10/2016	0.001	0.01	0.1	1	4.2
	S2	18/09/2017	0.01	0.01	0	0	4.1
UCh3.4	S1	20/10/2016	0	0.1	0	0	1.7
	S2	18/09/2017	0.1	0	0	1	3.9
NE1.1	S1	22/11/2015	0.001	0.001	0.01	1	9.1
	S2	20/02/2017	0.01	0.01	0.01	0	7.3
NE2.1	S1	22/11/2015	0.001	0.001	0.01	0	7
	S2	20/02/2017	0.1	0.1	0	0	5.5
NE3.1	S1	22/11/2015	0.1	0.1	0	0	0.29
	S2	20/02/2017	0.1	0	0	0	2
NE1.2	S1	11/05/2016	0.001	0.001	0.01	1	112
	S2	17/05/2017	0.001	0.001	0.01	1	261

Continued.

Sampled points	Sample number	Date of sampling	*E. coli*	*Proteus*	*Cl. prefringens*	*Salmonella*	Total bacteria, CFU/g×10^6
NE2.2	S1	11/05/2016	0.01	0.01	0.1	0	1.3
	S2	17/05/2017	0.01	0.01	0.1	0	6.2
NE3.2	S1	11/05/2016	0.1	0.1	0.1	0	3.5
	S2	17/05/2017	0.01	0	0	0	4
NE1.3	S1	25/07/2016	0.0001	0.0001	0.01	0	21
	S2	05/07/2017	0.001	0.001	0.01	1	195
NE2.3	S1	25/07/2016	0.001	0.001	0.01	0	0.8
	S2	05/07/2017	0.001	0.001	0.1	0	4.9
NE3.3	S1	25/07/2016	0.1	0.1	0	0	1.5
	S2	05/07/2017	0.01	0	0	0	6.3
NE1.4	S1	20/10/2016	0.001	0.001	0.01	0	8.5
	S2	18/09/2017	0.01	0.01	0.1	0	18.7
NE2.4	S1	20/10/2016	0.01	0.01	0	0	6.6
	S2	18/09/2017	0.1	0.1	0	0	3.6
NE3.4	S1	20/10/2016	0.1	0	0	0	5.3
	S2	18/09/2017	0	0.1	0	0	3
MD1.1	S1	20/02/2017	0.01	0.01	0.01	1	11.2
MD2.1	S1	20/02/2017	0.1	0.1	0.1	0	9.8
MD3.1	S1	20/02/2017	0.01	0.01	0	0	4
MD1.2	S1	17/05/2017	0.001	0.001	0.01	1	27.5
MD2.2	S1	17/05/2017	0.1	0.1	0.01	0	15
MD3.2	S1	17/05/2017	0.1	0.1	0	0	3.7
MD1.3	S1	05/07/2017	0.01	0.01	0.1	1	9
MD2.3	S1	05/07/2017	0.1	0.1	0.1	0	4.4
MD3.3	S1	05/07/2017	0.1	0.1	0	0	2.2
MD1.4	S1	18/09/2017	0.1	0.1	0	1	11.5
MD2.4	S1	18/09/2017	0.1	0.1	0	0	7.9
MD3.4	S1	18/09/2017	0	0.1	0	0	4.4
TsD1.1	S1	22/11/2015	0.001	0.001	0.001	1	69
	S2	20/02/2017	0.001	0.001	0.01	1	15.6
TsD2.1	S1	22/11/2015	0.01	0.01	0.001	1	5.4
	S2	20/02/2017	0.01	0.01	0	0	9.1
TsD3.1	S1	22/11/2015	0.01	0.01	0	0	0.41
	S2	20/02/2017	0.1	0.1	0	0	0.11
TsD1.2	S1	11/05/2016	0.0001	0.0001	0.001	1	321
	S2	17/05/2017	0.001	0.001	0.001	0	335
TsD2.2	S1	11/05/2016	0.01	0.01	0	0	13.5
	S2	17/05/2017	0.001	0.001	0	0	7.1
TsD3.2	S1	11/05/2016	0.01	0.01	0.01	1	9.5
	S2	17/05/2017	0.1	0	0.1	0	8.5
TsD1.3	S1	25/07/2016	0.00001	0.00001	0.001	1	14
	S2	05/07/2017	0.001	0.001	0.01	1	460
TsD2.3	S1	25/07/2016	0.01	0.01	0.001	1	3.3
	S2	05/07/2017	0.001	0.001	0	0	11.6
TsD3.3	S1	25/07/2016	0.01	0.01	0	0	0.21
	S2	05/07/2017	0.01	0	0.1	0	10.4
TsD1.4	S1	20/10/2016	0.001	0.001	0.01	1	7.2
	S2	18/09/2017	0.01	0.01	0	0	22
TsD2.4	S1	20/10/2016	0.01	0.01	0.01	0	5
	S2	18/09/2017	0.1	0	0	0	7.5
TsD3.4	S1	20/10/2016	0.1	0.1	0	0	0.39
	S2	18/09/2017	0	0	0	0	0.38
Control	S1	26/12/2016	0	0	0	0	0.19

Continued.

Sampled points	Sample number	Date of sampling	*E. coli*	*Proteus*	*Cl. prefringens*	*Salmonella*	Total bacteria, CFU/g×10^6
Winter	S2	20/02/2017	0	0	0	0	0.11
Control Spring	S1	11/05/2016	0	0	0	0	0.3
	S2	17/05/2017	0	0	0	0	0.014
Control Summer	S1	25/07/2016	0	0	0	1	0.11
	S2	05/07/2017	0	0	0	0	0.038
Control Fall	S1	20/10/2016	0	0	0	0	0.22
	S2	18/09/2017	0	0	0	0	0.029

nd - not detected, + salmonella detected in 25 ml.

Table 3: Comparison of heavy metals concentration in landfills (mg/kg of dry matter).

Landfill site	Sampled point	Sample	Sampling date	Pb	Cr	Ni	Zn	Cd
Ulaan Chuluut closed landfill site	TsD1.2	S1	11/5/2016	15.1	6.1	35.3	68.9	0.088
		S2	23/05/2017	22	70	46	78	0.04
	TsD1.4	S1	10/10/2016	19	67	21	84	0.21
		S2	19/09/2017	19	68	24	79	0.2
	TsD2.2	S1	11/5/2016	14.6	12.4	20.8	93.5	0.195
		S2	23/05/2017	12	62	84	77	0.13
	TsD2.4	S1	10/10/2016	14	34	6	50	0.1
		S2	19/09/2017	19	60	47	74	0.2
	TsD3.2	S1	11/5/2016	4.9	0.4	31.5	146.3	0.055
		S2	23/05/2017	17	70	44	67	0.23
	TsD3.4	S1	10/10/2016	13	81	26	80	0.47
		S2	19/09/2017	22	53	14	69	0.2
	Mean±SD			15.97± 4.81	48.66± 28.06	33.30± 20.46	80.56± 23.26	0.18± 0.11
	Control TsD		10/10/2016	21	47	13	73	0.19
Narangiin Enger landfill site	NE1.2	S1	11/5/2016	2.2	7.5	3.2	175.9	0.115
		S2	23/05/2017	51	53	16	153	0.16
	NE1.4	S1	10/10/2016	31	44	7	96	0.2
		S2	19/09/2017	37	64	27	129	0.21
	NE2.2	S1	11/5/2016	1.6	10.9	11.8	62.7	0.02
		S2	23/05/2017	13	32	7	57	0.03
	NE2.4	S1	10/10/2016	62	2519	16	438	1.86
		S2	19/09/2017	125	5124	17	776	2.84
	NE3.2	S1	11/5/2016	0.1	10.8	42	91.5	0.008
		S2	23/05/2017	13	39	9	60	0.02
	NE3.4	S1	10/10/2016	6	160	59	102	0.21
		S2	19/09/2017	61	1117	20	198	0.56
	Mean±SD			33.58± 36.90	765.10± 1562.67	19.58± 16.24	194.93± 210.42	0.52± 0.89
	Control NE		10/10/2016	14	48	9	64	0.12
Morin Davaa landfill site	MD1.1	S1	23/05/2017	29	439	34	159	0.87
	MD1.2	S2	30/10/2017	28	83	15	87	0.45
	MD2.1	S1	23/05/2017	17	59	24	41	0.01
	MD2.2	S2	30/10/2017	63	236	28	231	0.45
	MD3.1	S1	23/05/2017	32	55	20	50	<0.01
	MD3.2	S2	30/10/2017	33	60	10	101	0.23
	Mean±SD			33.67± 15.46	155.33± 155.33	21.83± 8.73	111.50± 72.11	0.40± 0.33
	Control 3		23/05/2017	17	81	20	55	<0.01

Continued.

Landfill site	Sampled point	Sample	Sampling date	Pb	Cr	Ni	Zn	Cd
Tsagaan Davaa landfill site	TsD1.2	S1	19/05/2016	3.7	7.3	19.5	49.6	2.195
		S2	23/05/2017	32	57	20	107	0.23
	TsD1.4	S1	10/10/2016	20	70	22	92	0.15
		S2	19/09/2017	19	69	20	94	0.26
	TsD2.2	S1	19/05/2016	6.1	15.1	32.2	25.9	1.985
		S2	23/05/2017	20	51	17	90	0.06
	TsD2.4	S1	10/10/2016	19	78	26	87	0.2
		S2	19/09/2017	21	73	31	88	0.2
	TsD3.2	S1	19/05/2016	12.6	29.5	43.9	21.7	0.258
		S2	23/05/2017	21	69	24	96	0.09
	TsD3.4	S1	10/10/2016	11	52	12	57	0.1
		S2	19/09/2017	19	76	24	78	0.2
	Mean±SD			17.03± 7.62	53.91± 24.20	24.30± 8.34	73.85± 28.39	0.49± 0.75
	Control TsD		10/10/2016	25	75	20	108	0.26
Mean±SD				23.83± 22.13	270.10± 871.86	25.17± 15.54	115.74± 124.85	0.39± 0.64
Control of out of urban				17	42	12	47	0.12
Mongolian norm*		Precaution value		100	150	150	300	3

*MNS 5850:2008 Soil quality. Soil pollutants and substance.[28]

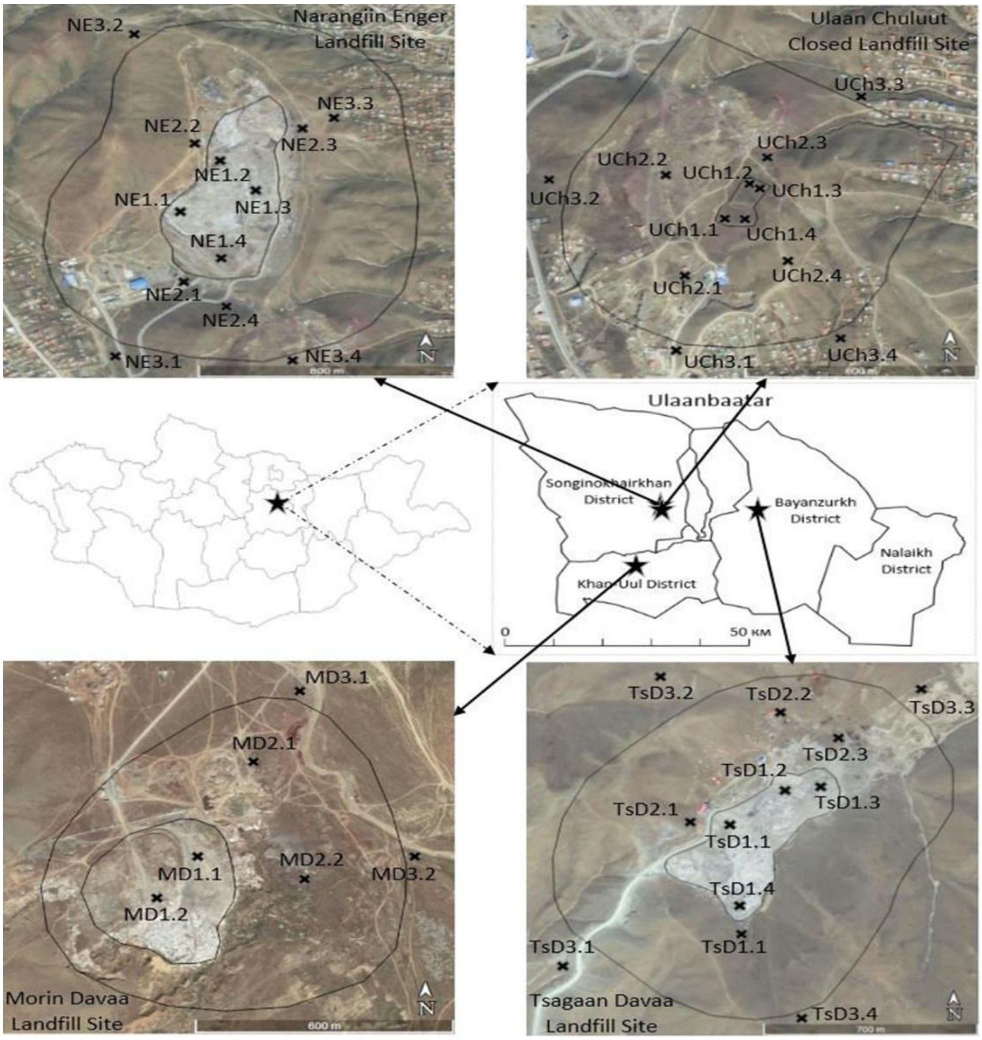

Figure 1: Localization of sampled points.

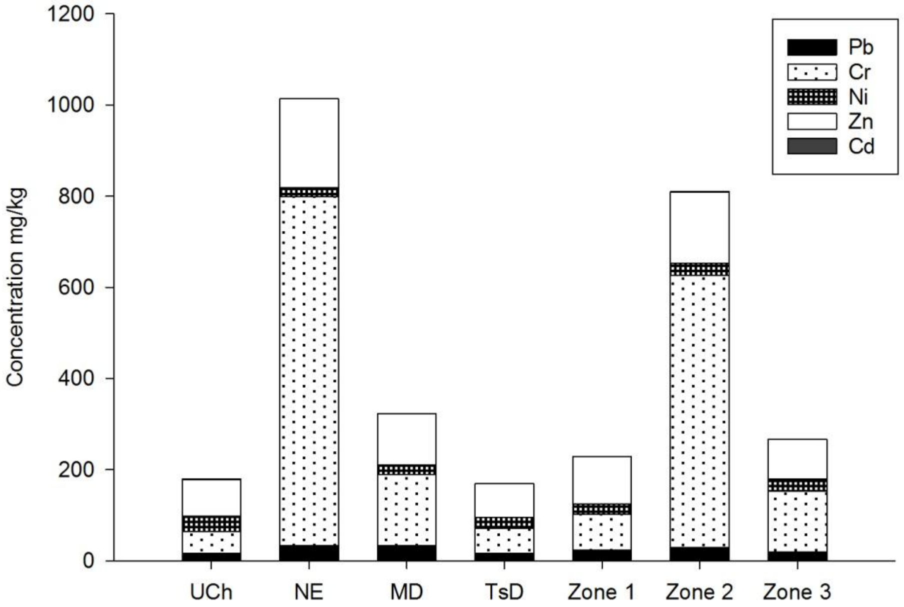

Figure 2: Concentrations (mg/kg of dry matter) of heavy metals in landfill sites and zones.

Table 4: Analysis of variance of the number of bacterial indicators and heavy metals in soil according to the landfill sites, zones and season of the year.

Indicators	Site		Zone		Season	
	F	p	F	p	F	p
Titre of *E. coli*	2.751	0.048	6.848	0.002	0.365	0.779
Titre of *Proteus*	5.424	0.002	7.736	<0.001	0.232	0.874
Titre of *Cl. perfringens*	0.821	0.486	0.383	0.683	0.598	0.618
Presence of *Salmonella*	1.086	0.360	14.226	<0.001	0.071	0.975
Total bacteria	1.365	0.259	7.594	<0.001	2.753	0.048
Pb	2.24	0.10	0.73	0.49	-	-
Cr	1.96	0.14	1.52	0.23	-	-
Ni	1.82	0.16	0.40	0.68	-	-
Zn	2.67	0.06	1.19	0.31	-	-
Cd	0.73	0.54	1.44	0.25	-	-

F-among goups variance, p-significance level

In Mongolia, landfills are covered with soil from nearby places instead of daily cover material thus concentration of some heavy metals (Pb, Cr, Zn and Cd) in zone 1 is less than in zone 2. Concentration of some heavy metals in zone 2 is higher than in other zones due to its daily activity and all the studied landfills that are unlined (Figure 2).

Correlation analysis made between content of heavy metals and bacterial indicators showed no significant relationship.

According to Table 4, statistical analysis demonstrated that:

- The titre of *E. coli* for the MD landfill site (M=0.06, SD=0.05) was significantly different than the TsD landfill site (M=0.02, SD=0.04); the titre of *Proteus* for the MD landfill site (M=0.07, SD=0.05) was significantly different than the TsD landfill site (M=0.01, SD=0.03) and the NE landfill site (M=0.03, SD=0.04). However, titre of *Cl. perfringens*, presence of *Salmonella*, total bacteria did not significantly differ for landfill sites.
- The titre of *E. coli* for the zone 1 (M=0.001, SD=0.03) was significantly different than the zone 3 (M=0.05, SD=0.05); the titre of *Proteus* for the zone 1 (M=0.001, SD=0.03) was significantly different than the zone 3 (M=0.05, SD=0.05); the presence of *Salmonella* for the zone 1 (M=0.64, SD=0.49) was significantly different than the zone 2 (M=0.14, SD=0.36) and zone 3 (M=0.14, SD=0.36); the total bacteria for the zone 1 (M=74.45, SD=122.70) was significantly different than the zone 2 (M=6.05,

SD=3.49) and zone 3 (M=10.03, SD=35.19). But, titre of *Cl. perfringens* did not significantly differ for landfill zones.
- The bacterial indicators did not significantly differ for seasons of the year.

Heavy metals on landfill sites and zones had no significant effect (Table 4).

DISCUSSION

In the present study, we investigated bacterial and heavy metal pollution in four landfill sites. Unlimited and uncontrolled contamination spread through these unlined landfills.

According to our result, for the MD landfill which receives industrial waste, the titre of *E. coli* site was significantly different than the TsD landfill site, the titre of *Proteus* was also significantly different from the TsD and the NE landfill sites. Samples were examined for frequency of isolation of viable aerobic heterotrophic bacterial and fungi from four different station of a dump site in Port Harcourt City. There were no significant differences in the bacterial and fungal population between the four stations.[26]

While results of the investigations conducted for this study show that bacteria from the genus *Salmonella* were not detected in any of the collected soil samples on the premises and in the vicinity of the Municipal Landfill Site and the Municipal Solid Waste Management Plant in Toruń.[27] Our study revealed that *Salmonella* were founded in all landfill sites.

Samples were collected from ash of the burned waste near the landfill sites in Ulaanbaatar to identify content of heavy metals including Pb, Cr, Cd, Ni and Zn. There are total of 300 mg/kg Cr and 700 mg/kg Zn identified from ash of burned electrical wire, 1000 mg/kg Pb is identified from the ash of burned tires. These open burnings have considerable influences on polluted soil with heavy metals.[29]

Heavy metals in the landfill – suggest that the long-existing and -operating metal-processing, wood and chemical industries did not prove to be a significant metal pollution source by their deposited wastes to the nearby closed unlined landfill.[30] Anthropogenic inputs derived from leachate are among the contamination sources that directly impacted the soils of Bizerte landfill.[31] Among environmental pollutants, heavy metals are of particular concern due to their toxicity, wide source, non-biodegradable properties, and their ability to accumulate for long period of time.[31, 32]

Need of constant monitoring of microbiological contamination emissions, in particular those within the landfill, for a threat to people who work in that area.[33] Reclaimed landfill cell continues to be a source of soil contamination. Soil contamination may be caused by bioaerosol forming on the landfill site, and by animals–mainly birds, rodents, stray dogs, and cats.[27] The principal threat to groundwater comes from inadequately controlled landfills where leachate generated from the fill is allowed to escape to the surrounding and underlying ground. To minimise the impact of such landfills on groundwater quality and the environment in general, it is necessary to properly design and build these facilities to prevent pollution.[34]

Managing waste disposal, landfills, and dumps is a crucially important issue for maintaining a safe and sustainable environment across Asia. However, waste disposal practices in the developing countries of the region are poor, and the many open dumps pose serious health and environmental risks.[35]

Many cities in developing Asian countries face serious problems in managing solid wastes. The annual waste generation increases in proportion to the rises in population and urbanisation. Asian countries with greater rural populations produce more organic waste, such as kitchen wastes, and fewer recyclable items, such as paper, metals, and plastics.[36] A good waste classification system is the foundation and precondition for efficient waste management.[37] Recyclables are collected from wastes received in landfill sites due to the resource classification system is not developed in UB.

The practice of covering landfills with soil 30 cm thick was started, and this continued in most areas of Japan in the 1960s. With intermediate cover, it was called the sandwich-like landfill method, but there was no technical standard until 1971.[38] This technology has been being used in Mongolia since 2009.

To overcome the problem, the management aspect should be systematic and efficient not only at the early phase of operation but also during and after the landfill is closed from active operation. A regime of actions required to manage the issues of heavy metal pollution require substantial reduction of the waste sources through application of integrated management of waste through reducing generation of wastes at their respective source; recycling, compositing and thermal burning which could reduce the concentration of heavy metal in the wastes.[11] Re-designing of sanitary landfill with clay or plastic liners to prevent leachate from getting to water table, adoption of clean technology for recycling greenhouse gases emanating from the landfill and a sustainable land management programmed for reclamation are needed.[39] Rehabilitation of old unlined landfills should take place with continuous monitoring programs of ground water sources around the area to contain any contamination that might occur.[40]

The development of integrated waste management system and enhancing the final disposal technology has become one of the social challenges in Mongolia.

Microbiological contamination and content of heavy metals in closed unlined landfill are not different from currently operating unlined landfills. Average content of heavy metal pollution of landfills did not exceed precaution value but it is higher than in the control soil. The unlimited and uncontrolled contamination is a strong factor in this pollution accumulation. Liner system for avoiding of pollution spreading and daily cover material for saving the environment from landfill bacterial pollution are recommended.

ACKNOWLEDGEMENTS

The authors would like to thank the “Administration of Mongolian University of Life Science” for providing financial support to conduct the research and “Landfill sites management office” (Under the Governor of the Capital City**)** for their cooperation and data availability.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. El-Fadel M, Findikakis AN, Leckie LO. Environmental impacts of solid waste landfilling. J Environ Manage. 1997;50:1–25.
2. Swati, Ghosh P, Das MT, Thakur ISh. In vitro toxicity evaluation of organic extract of landfill soil and its detoxification by indigenous pyrene-degrading Bacillus sp. ISTPY1. Int Biodeter Biodeg. 2014;90:145–51.
3. Adamcová D, Vaverková MD, Barton S, Havlícek Z, Broušková E. Soil contamination in landfills: a case study of a landfill in Czech Republic. Solid Earth. 2016;7:239-47.
4. Teta Ch, Hikwa T. Heavy Metal Contamination of Ground Water from an Unlined Landfill in Bulawayo, Zimbabwe. J Health Pollution. 2017;15:18-27.
5. Ministry of Nature, Environment and Tourism Mongolia. State of the Environment Report Mongolia. Ulaanbaatar, 2015-2016: 218-220.
6. Breza-Boruta B, Lemanowicz J, Bartkowiak A. Variation in biological and physicochemical parameters of the soil affected by uncontrolled landfill sites. Environ Earth Sci. 2016;75:201.
7. Raman N, Narayanan DS. Impact of solid waste effect on ground water and soil quality nearer to Pallavaram solid waste landfill site in Chennai. Rasayan J Chem. 2008;4:828-36.
8. Minjmaa B, Oyunchimeg T. Effect of Landfills in Ulaanbaatar on Environment. Mongolian J Agricultural Sci. 2017;1:65-172.
9. Bouzayani F, Aydi A, Abichou T. Soil contamination by heavy metals in landfills: measurements from an unlined leachate storage basin. Environ Monit Assess. 2014;186:5033–40.
10. Igborgbor JC, Ogu GI. Microbial Assessment of Air In The Vicinity Of Some Dump Sites in Delta State. IOSR J Engineering. 2015;1:07-15.
11. Ogunmodede OT, Ojo AA, Adebayo OL. Assessment of Microbial and Heavy Metal Concentration per Distance and Depth at a Municipal Solid Waste Landfill. Int Letters Natural Sci. 2014;22:1-13.
12. Obasi NA, Akubugwo EI, Ugbogu OC, Otuchristian G. Assessment of Physico-chemical Properties and Heavy Metals Bioavailability in Dumpsites along Enugu-port Harcourt Expressways, South-east, Nigeria. Asian J Applied Sci. 2012;5:342-56.
13. Osazee OJ, Obayagbona ON, Daniel EO. Microbiological and physicochemical analyses of top soils obtained from four municipal waste dumpsites in Benin City, Nigeria. Int J Microbiol Mycol. 2013;1:23-30.
14. Integrated Legal Information System. Fact sheet: Order No. 404 of Mongolian Minister of Nature and Environment (2006). Procedure for activities of individuals, business entities and organizations to landfill and requirements for waste disposal and destruction, dedicated facility, landfill type. Available at: http://www.legalinfo.mn/annex/details/5151?lawid=8119. Accessed on 28 June 2019.
15. Integrated Legal Information System. Fact sheet: Law on waste, 2017. Available at: http://www.legalinfo.mn/law/details/12652. Accessed 28 June 2019.
16. National standard system. Fact sheet: MNS 3298-90 Environmental protection. Soil. General requirements on the probe for analytical purposes. https://www.estandard.gov.mn/file.php?sid=1389. Accessed on 18 March 2018.
17. National standard system. Fact sheet: MNS 2305:1994 Soils. Sampling, packing, transformation and keeping of samples. Available at: https://www.estandard.gov.mn/file.php?sid=1408. Accessed on 18 March 2018
18. National standard system. Fact sheet: Black CA (1965) Methods of Soil Analysis: Part I Physical and mineralogical properties. Madison, Wisconsin
19. National standard system. Fact sheet: Jackson M.L (1969) Soil chemical analysis - Advanced course. Wisconsin Madison, Wis. 1969.
20. National standard system. Fact sheet: MNS 9297:1991 Environment protection. Soil. The indicator of norm sanitation for soil communities. Available at: https://www.estandard.gov.mn/file.php?sid=1388. Accessed on 18 March 2018.
21. ISO 9308-1:2014 Water quality — Enumeration of Escherichia coli and coliform bacteria — Part 1: Membrane filtration method for waters with low bacterial background flora.
22. MNS 5668: 2006 Examination of biological properties of water. Method for microbiological of waste water, 2006.

23. ISO 14189 Water quality — Enumeration of Clostridium perfringens — Method using membrane filtration.
24. ISO 19250:2010 Water quality — Detection of Salmonella spp.
25. Netrusov AI, Egorova MA, Zakharchuk Practice microbiology. Academy, Moskva; 1993.
26. Obire O, Nwaubeta O, Adue SBN. Microbial community of a waste-dump site. J Appl Sci Eniron Mgt. 2002;6(1):78-83.
27. Kalwasińska A, Swiontek-Brzezinska M, Burkowska A. Sanitary Quality of Soil in and near Municipal Waste Landfill Sites. Pol J Environ Stud. 2012;6:1651-7.
28. National standard system. Fact sheet: MNS 5850: 2008 Soil quality. Soil pollutants and substance. 2008. Available at: https://www.estandard.gov.mn/file.php?sid=436. Accessed on 18 March 2018.
29. Minjmaa B, Oyunchimeg T. Sources of heavy metal contamination in landfill soil covers of Ulaanbaatar. Mongolian J Agricultural Sci. 2017;22(03):140-4.
30. Kasassi A, Rakimbei P, Karagiannidis A, Zabaniotou A, Tsiouvaras K, Nastis A, et al. Soil contamination by heavy metals: Measurements from a closed unlined landfill. Bioresource Technol. 2008;99(18):8578-84.
31. Aydi A. Assessment of heavy metal contamination risk in soils of landfill of Bizerte (Tunisia) with a focus on application of pollution indicators. Environ Earth Sci. 2015;74:3019–27.
32. Dong JH, Yu M, Bian ZF, Wang Y, Di CL. Geostatistical analyses of heavy metal distribution in reclaimed mine land in Xuzhou. China. Environ Earth Sci. 2011;62(1):127–37.
33. Burkowska A, Brzezinska MS, Kalwasińska A. Impact of the Municipal Landfill Site on Microbiological Contamination of Air. Contemporary Problems of Management and Environmental Protection. 2011;9:71-87.
34. Shaikh Parveen R, Bhosle Arjun B, Yannawar Vyankatesh B. The impact of landfill on soil and groundwater quality of the Nanded city, Maharashtra. Researcher. 2012;4(7):56-63.
35. Inanc B, Idris A, Terazono A, Sakai Sh. Development of a database of landfills and dump sites in Asian countries. J Mater Cycles Waste Manag. 2004;6:97–103.
36. Idris A, Inanc B, Hassan MN. Overview of waste disposal and landfills/dumps in Asian countries. J Mater Cycles Waste Manag. 2004;6:104–10.
37. Wen X, Luo Q, Hu H, Wang N, Chen Y, Jin J, et al. Comparison research on waste classification between China and the EU, Japan, and the USA. J Mater Cycles Waste Manag. 2014;16:321–34.
38. Tanaka N, Tojo Y, Matsuto T. Past, present, and future of MSW landfills in Japan. J Mater Cycles Waste Manag. 2005;7:104–11.
39. Akinbile ChO, Yusoff MS. Environmental Impact of Leachate Pollution on Groundwater Supplies in Akure, Nigeria. Int J Environ Sci Develop. 2011;2(1):81-6.
40. Raisi SAHA, Sulaiman H, Suliman FE, Abdallah O. Assessment of Heavy Metals in Leachate of an Unlined Landfill in the Sultanate of Oman. Int J Environ Sci Develop. 2014;5(1):60-3.

Cite this article as: Byamba-Ochir M, Tugjjav O. Microbiological contamination and content of heavy metals in unlined landfill sites of Ulaanbaatar. Int J Sci Rep 2019;5(8):190-200.