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Investigation on heavy metals pollution of municipal refuse leachate from Tromsø landfill, Northern Norway

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Abstract. To investigate the heavy metal pollution in leachate from sanitary landfill site of municipal solid waste, a survey was conducted in Tromsø Northern Norway. Results shows that contents of heavy metals in landfill leachate follow the order Mn>Zn>Ni>Cu>Cr>As>Pb>Cd>Hg, and the order of the risk of different heavy metals is: Mn>Ni>As>Zn>Cr>Pb>Cd>Hg>Cu. The concentrations of Mn and Ni in landfill leachate exceeded the standard. Mn had the highest single standard index. it took the highest risk to surround water and environment. According to comprehensive evaluation of water quality, the landfill leachate is moderately polluted. It is helpful for the control and management of leachate in garbage plants to know the degree and types of heavy metal pollution in leachate.

1. Introduction

With the rapid development of urban area and increase of urban population, the urban domestic garbage increased significantly throughout the years. It has become one of the major environmental problems now in the urban area, and a hotspot and a difficult point for environmentalists [1]. The goal of modern garbage disposal is to reduce, harmless and recycle [2]. At present, waste treatment methods include incineration method, composting method, sanitary landfill method and sorting method, among which incineration method and sanitary landfill method are most commonly used all around the world [3]. As the volume of landfill increases, it will accumulate and decompose for a long time, generate a large amount of leachate, and affect the surrounding environment [4].

Landfill leachate is a kind of sewage leachate which is infiltrated by the fermentation, rainwater scouring, runoff and groundwater immersion in the process of stacking and landfilling [5]. Landfill leachate mainly contain three aspects: (1) natural rainfall and runoff in the landfill; (2) the original water content of the garbage itself; and (3) water produced by anaerobic decomposition of microorganisms after the sanitary landfill [6]. The rainfall plays an important role in the landfill leachate. When the water seeps through the complicated garbage, the waste will be decomposed, dissolved, fermented, etc., thus the leachate contains a large amount of organic pollutants, nitrogen, phosphorus and heavy metal metals [4]. The variations of landfill leachate water quality is affected by the composition of garbage, water content of garbage, temperature of garbage, landfill time, landfill technology, rainfall infiltration and so on, among which the most important factor is the impact of rainfall and landfill time [7]. Landfill leachate is a complex high-concentration organic wastewater. Its properties depend on the composition of the waste, the particle size of the waste, the degree of



compaction, the climate, the site, hydrological conditions and landfill time [8]. Generally, the landfill leachate has the following characteristics: complex water quality, high risk; high organic content; high ammonia nitrogen content; high heavy metal content and variable water quality [9]. Recent studies have shown that [10], due to the complexity and difference of landfill sites, the composition of waste, the time of landfill and other factors, the composition of leachate in each landfill is different. In particular, because of the different ways of garbage classification and collection in different countries, the quality of landfill leachate in different regions varies greatly [11].

When the heavy metals released to landfill leachate, they can't be decomposed by soil microbes, and will enrich in organisms [12]. Once the soil layer and water is contaminated by heavy metals, it is difficult to eliminate, and thus pose a great threat to surrounding environment [13]. Understanding the heavy metal pollution characteristics in landfill leachate is beneficial for the control and prevention of landfill environmental risks [14]. In this study, we sampled the leachate of the landfill in Tromsø. The concentrations of As, Cd, Cr, Cu, Hg, Mn, Ni, Pb and Zn in the leachate were analyzed. The environmental risks of heavy metal pollution at the site were identified at last.

2. Materials and method

2.1. Study site

Tromsø (69°38'56"N, 18°57'18"E) is the capital of Norway's Troms County and the largest port city in northern Norway. Its location is close to the top of the European continent and is one of the most northern cities in the world. Tromsø is the seventh largest city in Norway and the most important port city in northern Norway. Tromsø is located on the island of Kvaløya in the Norwegian Sea Tromsø Strait and on a nearby island. The population is about 72,000 (2017). Because of the passage of the North Atlantic warm current, the winter is not frozen, it is a year-round non-freezing port. Tromsø is the centre of the Norwegian Arctic Ocean fishing and sea catching industry. Every year, polar day occurs from May 1st to July 23rd. The mean annual temperature and precipitation of Tromsø were 4.6 °C and 1417 mm in 2016. The temperature is between -13°C and 21.1°C. (69°38'56"N, 18°57'18"E, klima.met.no).

2.2. Sampling and measurement

Used buckets to collect landfill leachate from the landfill leachate Wells by, and then used 200ml Polyethylene plastic bottle to encapsulate the landfill leachate from buckets, each bucket sampled one bottle. Collect five samples, and then sealed in the incubator and brought back to the laboratory for analysis.

Samples were sent to ALS Scandinavia AS (<https://www.alsglobal.se/en>) for chemical composition analysis. Leachate was treated follow EPA 200.8. Heavy metals of landfill leachate were determined by an inductively coupled plasma atomic emission spectrometry (ICP-AES, PerkinElmer Optima 8300).

Mathematical statistics were done through SPSS24.0 software.

3. Result and discussion

3.1. Heavy metals content in the municipal refuse leachate

According to sampling analysis, the results of heavy metal content in landfill leachate are shown in table 1. Cd, Hg, Pb, As, Cr, Cu and Zn showed lower than the standards of EEC, WHO and EPA2001. Mn and Ni were higher than the standards of EEC, WHO and EPA2001, with the content of 972.80 µg/L and 20.66 µg/L, respectively. Of all the heavy metals analyzed, Mn had the highest content by 1130.00972.80 µg/L, and Hg had the lowest content by 0.02 µg/L. And the contents of heavy metals in landfill leachate showed the trend by Mn>Zn>Ni>Cu>Cr>As>Pb>Cd>Hg. Mn was 9 times higher than the standard of EEC and WHO. Ni was little higher than the standards, but the max value of Ni content was 3 times higher than the standards. When the heavy metal content in water exceeds the

standard value, it will inevitably cause pollution to the surrounding water and environment. So Mn and Ni take threat to surround water quality and environment.

Table 1. Concentrations of heavy metal in Troms landfill leachate.

Leaching	Mean ($\mu\text{g/L}$)	Max ($\mu\text{g/L}$)	Min ($\mu\text{g/L}$)	Std	98/93EEC ($\mu\text{g/L}$)	WHO ($\mu\text{g/L}$)	EPA2001 ($\mu\text{g/L}$)
As	0.91	1.32	0.63	0.308797	10	10	50
Cd	0.05	0.05	0.05	0	5.0	3	5
Cr	2.45	3.32	1.91	0.555401	50	50	100
Cu	3.28	10.50	1.00	4.048014	2000	2000	2000
Hg	0.02	0.02	0.02	0	1.0	1.0	2.0
Mn	972.80	1130.00	671.00	187.3705	100	100	50
Ni	20.66	71.70	4.85	28.65496	20	20	
Pb	0.50	0.50	0.50	0	10	10	/
Zn	186.80	242.00	152.00	33.1768		3000	5000

EEC: European Economic Community; WHO: World Health Organization; EPA: US Environmental Protection Agency

3.2. Environmental risk of municipal refuse leachate to surround water

There are many methods for evaluating water quality, mainly the index method system and the fuzzy math method (also called the gray method). In order to facilitate the uniform comparability of historical data, the single water quality assessment applied the single standard index method [15-17], the equation following:

$$A_i = C_i / C_{si}$$

where: A_i is the standard index of the i factor; C_i is the measured concentration of the factor.

Comprehensive evaluation of water quality using the comprehensive index WQI method [16,18]:

$$WQI = \frac{1}{n} \sum_{i=1}^n A_i$$

where: WQI is the water quality composite index; A_i is the standard index of the i factors; n is the number of items of all the water quality parameters evaluated. When the A or WQI value is less than 0.75, the water quality is clean, 0.75-1.0 indicates that the water quality is mildly polluted, 1-1.25 indicated the water quality is moderately polluted, and higher than 1.25 indicated the water quality is heavy polluted.

Table 2. Single and comprehensive index of landfill leachate quality.

	As	Cd	Cr	Cu	Hg	Mn	Ni	Pb	Zn	WQI
A_1	0.13	0.02	0.05	0.01	0.02	9.33	0.61	0.05	0.06	1.14
A_2	0.06	0.02	0.05	0.01	0.02	11.30	0.36	0.05	0.06	1.32
A_3	0.07	0.02	0.04	0.01	0.02	10.10	0.37	0.05	0.05	1.19
A_4	0.07	0.02	0.04	0.01	0.02	6.71	0.24	0.05	0.06	0.80
A_5	0.12	0.02	0.07	0.01	0.02	11.20	3.59	0.05	0.08	1.68
A_{mean}	0.09	0.02	0.05	0.01	0.02	9.73	1.03	0.05	0.06	1.23

As shown in table 2, the values of single standard index of As, Cd, Cr, Cu, Hg, Pb and Zn were small. Indicated that As, Cd, Cr, Cu, Hg, Pb and Zn took no pollution to surround water and environment. For the single standard index of Ni, four samples out of five showed clean with the value less than 0.75; and the other one showed heavy polluted by Ni. Mn were heavy pollution of all the samples by the single standard index. According to the single standard index, Mn had the highest

single standard index, indicated Mn took the highest risk to surround water and environment; Cu had the lowest single standard index, indicated it took lowest risk to the water; the single standard index of Ni is 1.03, so it moderately polluted surround water; the order of risk of different heavy metals to water is: Mn>Ni>As>Zn>Cr>Pb>Cd>Hg>Cu.

According to comprehensive evaluation of water quality, the results of WOI was shown in table 2. The values of WQI varied from 0.80 to 1.68, and with the mean value of 1.23. It indicates that the landfill leachate is moderately polluted. The sanitary landfill site is polluted with Mn and Ni, and Mn pollution is still very serious in the landfill site.

4. Conclusion

Heavy metals in landfill leachate pose a threat to the surrounding environment. Knowing the pollution degree of heavy metals in the landfill leachate is benefit for the controlling and management of landfill. In this study, the leachate of Tromsø landfill site was collected and analyzed, results showed that heavy metals in landfill leachate following the trend by Mn>Zn>Ni>Cu>Cr>As>Pb>Cd>Hg, and the order of the risk of different heavy metals is: Mn>Ni>As>Zn>Cr>Pb>Cd>Hg>Cu. The heavy metals of Mn and Ni in leachate of sanitary landfill exceed the standard, Mn had the highest single standard index, it took the highest risk to surround water and environment. According to comprehensive evaluation of water quality, the landfill leachate is moderately polluted. Understanding the pollution characteristics and degree of heavy metals in landfill leachate is beneficial to the control and treatment of landfill leachate.

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