THE ASSESSMENT OF AIR AND WATER QUALITY OF SHARRA LANDFILL

A. BANI[1]*, F. BRAHUSHI[1], E. ÇELA[1,2], S. MUSTAFAJ[3] E. JOJIÇ[1]

[1] Agricultural University of Tirana, Faculty of Agriculture and Environment

[2] Department of Waste Treatment, Municipality of Tirana

[3] Agricultural University of Tirana, Faculty of Economy & Agribusiness

*E-mail: aida_alushi@hotmail.com

Abstract

The waste disposal site of Sharra represents the first landfill for the management of solid wastes in Albania designed in accordance to the European Union standards for the management and administration of solid wastes. The objective of this study was to realize a general assessment of the environmental state in the areas nearby Sharra, after the implementation of the landfill as a remediation method. Water and air samples have been periodically collected and analyzed before and after the remediation of the waste disposal site of Sharra, respectively on the years 2008 and 2009. Results show that the measured indicators used to assess the quality of air such as; solid particles, PM10, NO_2, H_2S, CH_4 reach the respective average values of 372 µg m-3, 216 µg m-3, 97 µg m-3, 0.8 µg m-3, 350 µg m-3 in 2008 and 72 µg m-3, 30 µg m-3, 29 µg m-3, 0.22 µg m-3, 41 µg m-3, in the year 2009. Before the remediation, except H_2S the concentrations of all the other components in air exceed the Albanian and European Union limits whereas in 2009 these values have dropped under the mentioned limits. The concentration of heavy metals (mg L^{-1}) in the surface waters exceeds the allowed limits for Ni (0.002-0.08), Mn (0.6), Cr (0.19-0.33) and Fe (0.2-3.5). As regards to the quality of surface water; some of the indicators such as EC, Cl^-, NO_2^- resulted to surpass the above mentioned limits even after the implementation of the landfill. Based on the obtained results, further actions should be considered to be carried out in order to assure the collection and remediation of the landfill leaching prior they join the Erzeni River.

Key words: Landfill, waste management, air and water quality assessment

1. Introduction

Waste or garbage is any material generated from human activity which is considered to be useless, superfluous, valueless or unwanted and is disposed in the environment. After the collection, the garbage may be dumped into a landfill site or destined for composting, incineration or recycling. Solid wastes generated in urban areas may contain both domestic and commercial wastes, along with industrial wastes, thus composing a mixture of different compounds from which some are hazardous to human health. There are several risks associated with the waste disposal in the environment, like the contamination of soil, surface and underground water, air and consequently on the vegetation and animals.

The main routes for human exposure to the contaminants present in landfill sites are through dispersion in the ground and in contaminated air, and through percolation and seepage of leachates. The Sharra landfill is located in southwest of Tirana and is the principal dumping site used by the Municipality of Tirana for urban solid waste. The site is operated since 16 years as an uncontrolled open dump with constant open fires which emits in the environment different contaminants. Until 2008 the solid wastes have been simply dumped in Sharra without any further elaboration thus becoming hazardous for the health of citizens located around this site. This disposal site has a retention capacity of 292 000 ton/solid waste/ year (Urban and special non hazardous wastes). In a situation of increased population, extensive urbanization and development of the city, the dumping site of Sharra was included in the urban plan. On the basis of a preliminary risk assessment analysis [4], the dumping site presented a high-risk potential thus the remediation was immediately required. Therefore, landfill as remediation technology was proposed, where existing dumping are modified so that useful products are obtained from it, apart from preventing the further degradation of the area surrounding the existing landfill [17]. The remediation alternatives are evaluated using technical and legal criteria as well as environmental, social and economic criteria [5]. In 2007 started a project with the support of the Italian Government for remediation of Sharra dumping by applying landfill technology by using conventional methods of capping and biogas venting. Landfills serves as a waste collection with all the basic elements of operation, as cover of landfill side with polyethylene (HDPE), drainage system of water created by the waste, a system for transporting and burning of biogas produced from the decomposition of waste; modern technological tools and other items like these. This paper highlights the effectiveness of landfill as remediation methods by the assessment of air and water quality.

2. Materials and Methods

2.1 Site characterization

Sharra landfill is located about 7 km in the southwest of the Tirana city centre and about 400-500 m in the southwest of Sharra village. The area of Sharra is separated from Tirana by a small hill with altitude of about 250-300 m above the sea level. This hill also separates the catchment area for surface waters of the Tirana basin from the area of Erzen River. The landfill itself is located down-slope on the right side of a small valley, at altitude of about 95 to 125 m. The bottom of the valley carries the Sharra stream. The Sharra stream flows from the hilly area of Sharra village to Erzen river at about 1.4 km in south of the landfill. In the upper part of the stream is situated an artificial reservoir. Due to the active surface erosion in this area, both slopes of the valley are very steep with an angle of about 40° to 50°, particularly steep is the right slope on which the landfill is located.

The climate of Tirana is characterized from dry and hot summers and wet and relatively cold winters. The annual average temperature is about 15.3° C. The mean temperature in the summer is about 23.2°C and in winter is about 7.4° C. The average rainfall is around 1247 mm/year and the wettest period is from October to February with about 70-75% of total rainfall.

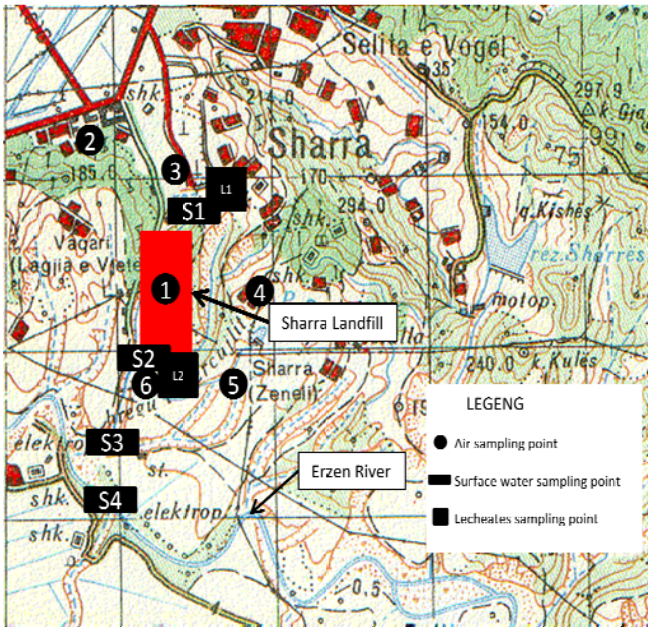

Figure 1. Map of Sharra Landfill and sampling points

2.2 Sampling

The air samples have been collected in 6 different points within this area in order to get a general view of the gas emissions in air, generated from Sharra landfill. The specific sites where the air and water samples have been collected are: point 1 was in the centre of landfill; point 2 was 500 m in north west of the landfill; point 3 was 300 m in the north of the landfill; point 4 was 300 m in the east of the landfill; point 5 was 200 m in the south-west of the landfill; point 6 was 100 m in south of the landfill (Figure 1).

The air samples were collected randomly on calm days during June 2005, June 2008 March 2009 and December 2009, in order to analyze the concentration of solid particles, PM_{10}, H_2S, NO_2 and CH_4 in the air. During the sampling in 2005, fires in the landfill were very frequent, as the burning was the only waste management method. The air sampling was realized in accordance with the Standard Methods of Air Sampling and Analysis [15]. The air analyses for the year 2005 and 2008 have been carried out in the Laboratory of Environmental Studies Institute of Tirana and for the year 2009 have been realized in the

Laboratory of Gesteco in the municipality of Povolettos (UD-Italy).

The water samples have been collected in four different points, as follow: Sample S1 in the existing basin of the hill where the landfill is located; sample S2 in the basin of Sharra stream where leachates percolates from the landfill (the collector of the spill); sample S3 very closed to the downstream confluence with Sharra stream; sample S4 in the upstream confluence with the Sharra stream. Also, two landfill lecheates samples (L1 and L2) were collected. The water samplings were conducted during July 2008, March 2009, July 2009, December 2009 and May 2010.

2.3 Air and water analyses procedures

The concentration of the total suspended matter (particle) (TSM) in the air samples was determined by the gravimetric method (the method of filtration at low volumes). This method consists on filtering the atmospheric air in quartz fiber filters which allow the penetration of particles with diameter less than 100 μ which were deposited in an electrostatic paper filter which carries all the dust particles with dimensions of 0.2-100 microns. Inhalation of air is realized with the help of vacuum pump with flow 5 l/min for 24 hours. The concentration of TSM was determined by calculation the difference between the filter weight before and after exposure in relation to the amount of air volume. The filter was previously dried until reaching the constant weight. The atmospheric concentration of TSM (μg $m^{-3)}$ was calculated by the equation:

$C = (m_2-m_1)/V$

where: C-concentration of TSM in μg m^{-3}, m_1-filter mass before exposure in μg, m_2-filter mass after exposure in μg, V- the inhaled air volume in m^3.

PM_{10} (suspended matter under 10 microns) in atmospheric air was determined also by gravimetric method. Atmospheric air is filtered in quartz fiber filters or cellulose filter which allows the penetration of the particles with diameter less than 10 μ which were deposited in a cellulose filter (Watman 47mm, diameter of pores 0, 8 μ). The inhalation of air is performed by a vacuum pump with a speed flow of 6 l/min. The concentration of PM_{10} was determined as the difference between the filter mass before and after exposure in relation to the amount of air volume.

For determining or measuring the NO2 content was used 2EN 14211:2005 "Ambient air quality – Standard method for the measurement of the concentration of nitrogen dioxide in ambient air based on the chemiluminescence measuring principle [15]. The method was performed by an automatic analyzer (Fluorescence NO2 automatic analyzer Model 200E). The method allows measuring of the concentration of nitrogen dioxide present in ambient air from 0 mg m-3 to 500 mg m-3. The concentrations of H2S, CH4, were simultaneously recorded by the automatic air-monitoring (Orion plus MSA).

The water samples were analyzed in the Laboratory of Gesteco in the municipality of Povolettos (UD-Italy) by using ISO 15586: 2003, method for Water quality. The determination of heavy metals was realized by using atomic absorption spectrometry with Graphite oven method [16].

3. Results and Discussion

The results showing the solid particle and PM_{10} concentrations in the area of Sharra for the years 2008 and 2009 are presented in the tables 1, 2, 3 and figure 2. Results for the year 2005 and 2008 (when the Sharra landfill was under burning method of waste management and remediation process had not started) showed the maximum values of TSM and PM_{10} with concentrations of about 742 and 326 μg m^{-3} for the year 2005 and 372 and 216 μg m^{-3} for the year 2008, respectively. The European air quality regulations predetermine that the average solid particle and PM_{10} concentrations should not exceed respectively 80 and 40 μg m^{-3}. In urban areas of neighboring countries, the reported mean values of PM_{10} concentrations are: 75 μg/m^3 for Athens, Greece [18, 12], 72 μg m^{-3} for Sophia, Bulgaria [10], 51 μg m^{-3} for Genoa, Italy [3, 12], 75 μg m^{-3} for Bucharest, Romania [10]. By comparing these data, with the results from Sharra landfill, it is clearly noticeable that the concentrations of the solid particles and PM_{10} in Sharra's air significantly exceed the EU and Albanian limits for these components in air. Comprehensive toxicological and epidemiological studies conducted over the last decades have implicated that human exposure to such small airborne particles (PM_{10}) present adverse health effects and may be the cause of different respiratory and cardio vascular inflammations.

The TSM and PM_{10} concentrations on March 2009 were 72 and 30 µg m^{-3}, respectively, these values result to be much lower than the values of the year 2005 and 2008. By comparing the results between March 2008 and March 2009 (when the landfill was subject to new waste management methods) it can be clearly noticed the improvement of air quality in the area. In general, the levels of the PM_{10} concentrations in the Sharra area may be reputed as a reliable indicator of high air pollution in 2005, 2008 and indicating the necessity of remediation.

Hydrogen sulphide (H_2S), produced by bacteria activity, is a colorless gas that can cause a distinct odor at low concentrations such as 0.7 µg m^{-3} [1]. The average concentration of H_2S detected on June 2008 was 0.8 µg m^{-3}, this value stands below the allowed limits [14], but can still cause unpleasant odors. This means that odors produced from the landfill do have more a nature of a public nuisance rather than a community health hazard. However, for some people, simply smelling an unpleasant odor can be sufficient to create an adverse physiological response. While there are some concerns that odors might bring an asthmatic attack in highly sensitive people. A controlled study showed that the exposure of asthmatic to a high level of hydrogen sulfide (2800 µg m^{-3}) did not trigger an asthmatic attack or alter respiratory function [11].

Table 1. Results of air analysis in Sharra area on June 2008 (concentrations expressed in µg m^{-3})

Sampling Point	TSM	PM10	NO_2	H_2S	CH_4
1	160	75	70	0.4	140
2	280	130	80	0.6	260
3	840	540	160	1.6	650
4	210	120	80	0.6	160
5	370	200	100	0.8	300
6	372	231	92	0.8	250
Average concentration	372±244	216±168	97±32	0.8±0.4 1	293±185
Albanian limit	140	60	60	3	160
EU limit	100	40	40	2	100

Table 2. The air analysis in Sharra area on March 2009 (concentrations expressed in µg m^{-3})

Sampling Point	TSM	PM10	NO_2	H_2S	CH_4
1	80	35	35	0.3	40
2	100	45	30	0.26	50
3	70	25	26	0.17	20
4	78	32	30	0.2	52
5	72	30	34	0.27	56
6	32	18	20	0.12	28
Average concentration	72±22	30±9	29±5.5	0.22±14	41±14
Albanian limit	140	60	60	3	160
EU limit	100	40	40	2	100

Table 3. The comparison of TSM and CH_4 concentrations before and after application of the landfill

Sampling Station	*TSM*		*CH_4*	
	June 2008	December 2009	June 2008	December 2009
1	160	0.11	140	3.5
2	280	0.33	260	9.5
3	840	0.24	650	3.5
4	210	0.3	160	3.5
5	370	0.36	300	3.5
6	372	0.39	250	4.5

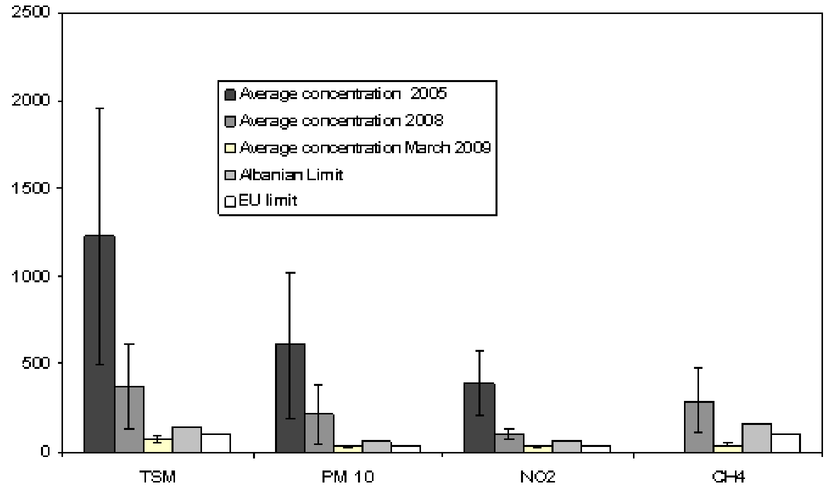

Figure 2. The comparison of TSM, PM10, NO_2 and CH_4 concentrations with Albanian and EU limit values (values for each indicator are given as mean values ± standard deviation).

Methane (CH_4) in municipal solid waste landfills is produced through anaerobic microbial degradation of organic matter. According to DeWalle *et al.* (1978) [9] higher rates of gas production occur in higher moisture conditions of the soil. The mixing of solid and liquid waste and a high groundwater level in the site results in a considerably high moisture content, and consequently a high rate of gas production. This fact might help to explain the exceptionally high value of 293 µg m-^{3} measured in June 2008 in ambient air at the site. Methane is flammable, but it is not associated with odors or hazards once emitted into the air. After the rehabilitation of Sharra landfill the conditions of methane production are stable and the values of CH_4 are within the acceptable levels (41 µg m^{-3} on March 2009, Table 2). The concentrations of the pollutant (NO_2) in the ambient air gas-phase, obtained at the different sampling stations of Sharra landfill are presented in the tables 1, 2 and 3. The higher concentration of NO_2 of 388 µg m^{-3} was recorded on 2005 (as TSM and PM_{10} concentrations) and this value is higher than the value measured in 2008 which stands over the acceptable limits. These high values are due to the combustion of solid wastes during this period. The concentration of NO_2 was 29 µg m^{-3} on March 2009. This value stands within the allowed limits and is a result of the actions carried out to rehabilitate the landfill such as the removal of old wastes and burning of biogas produced during the decomposition process of the wastes.

Comparing the obtained results with the Albanian and EU standard values for the selected indicators (see Figure 2), shows that the gas emission during 2005 and

2008 from Sharra landfill was 8 to 15 and 1 to 3.7 times higher than the limit values, respectively.

Some further results presented in table 3 (Figure 2), shows that the emission of gases at the end of 2009 is reduced due to the remediation process in this area.

The obtained results of water analysis are presented in table 4 and 4/1. These results show a variability of values between the different years and sampling points within the area. A pollution of surface waters was detected in the area of the landfill and some of the water quality indicators were over the acceptable limits. The higher values of the water quality indicators were detected in the basin of Sharra where leachates percolate from the landfill.

The values of some indicators such as conductivity, chlorine, manganese and chromium in the sample 2 were almost the same with the values of the lecheates which are generated directly from the landfill.

Table 4 and 4/1. The surface water analysis in Sharra area.

Parameters	Sample 1					Sample 2					Limits
	July 2008	March 2009	July 2009	Decem. 2009	May 2010	July 2008	March 2009	July 2009	Decem. 2009	May 2010	
Conductivity µs cm^{-1}	446	482	309	483	815	975	480	700	843	5300	
O_2 mg L^{-1}	ND	5.62	ND	2.8	<0.5	ND	0.31	ND	2.8	<0.5	
pH	8.64	7.28	8.2	7.8	7	7.7	7.13	7.8	7.8	7.7	
SO^-_4 mg L^{-1}	62.9	56.7	60	66.6	76.3	57	99.9	147	186	121	250
Cl^- mg L^{-1}	21.3	21.3	17.9	16.8	47.4	846	461	41.7	19.4	868	200
NO_3 mg L^{-1}	ND	ND	<0.1	1	15	10		<0.1	1	1	50
NH_4 mg L^{-1}	0.5	0.15	0.4	0.08	<0.02	150	100	0.4	0.02	6	
NO_2^- mg L^{-1}	ND	ND	1	0.015	<0.015	ND	ND	1	<0.015	0.015	0.5
Cu mg L^{-1}	ND	0.008	0.017	0.0006	0.005	0.003	0.007	0.014	0.0012	0.009	1
Ni mg L^{-1}	0.003	ND	0.06	0.002	0.006	0.05	ND	0.02	0.005	0.08	0.001
Pb mg L^{-1}	0.004	0.13	0.009	<0.001	<0.001	0.12	0.14	0.009	<0.001	0.009	0.01
Mn mg L^{-1}	ND	0.003	ND	0.0004	0.002	ND	0.002	ND	0.0006	0.616	0.05
Zn mg L^{-1}	ND	0.1	0.1	<0.05	<0.05	ND	0.18	0.008	<0.05	0.17	3
Fe mg L^{-1}	0.2	0.12	0.31	0.13	<0.05	1	0.003	0.36	2	1.7	0.2
Cr tot mg L^{-1}	ND	ND	0.129	0.002	0.0002	0.33	ND	0.022	0.0007	0.19	0.05

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Parameters	Sample 3					Sample 4					Limits
	July 2008	March 2009	July 2009	Decem. 2009	May 2010	July 2008	March 2009	July 2009	Decem. 2009	May 2010	
Conductivity µs cm^{-1}	310	430	358	364	291	326	447	378	366	460	
O_2 mg L^{-1}	ND	5.45	ND	2.5	<0.5		5.21	ND	2.2	<0.5	
pH	8.35	6.66	8	7.6	7.8	8.22	8.08	8.1	7.6	7	
SO^-_4 mg L^{-1}	52	44.8	72.5	7.1	36.8	48.5	37	72	7.1	41	250
Cl^- mg L^{-1}	12.4	8.87	6.6	3.2	4.7	10.6	14.2	6.6	2.8	34	200
NO_3 mg L^{-1}	ND	0.4	<0.1	2	1	ND	0.28	<0.1	2	1	50
NH_4 mg L^{-1}	0.3	0.2	0.4	0.07	0.03	0.3	0.4	0.4	0.05	6.1	
NO_2^- mg L^{-1}	0.2	0.4	1	<0.015	0.015	0.2	0.3	1	<0.015	4.7	0.5
Cu mg L^{-1}	ND	0.04	0.013	0.0022	0.0003	0.004	0.02	0.012	0.0011	0.013	1
Ni mg L^{-1}	0.001	ND	0.02	0.002	0.001	0.001	ND	0.01	<0.001	0.008	0.001
Pb mg L^{-1}	0.003	0.14	0.01	<0.001	<0.001	0.003	0.13	0.008	<0.001	0.005	0.01
Mn mg L^{-1}	ND	0.36	ND	0.0004	<0.0001	ND	0.022	ND	0.0003	0.004	0.05
Zn mg L^{-1}	0.003	0.155	0.09	<0.05	<0.05	ND	0.09	0.08	<0.05	<0.05	3
Fe mg L^{-1}	0.4	0.29	0.5	3.58	<0.05	0.3	0.2	0.35	2.3	0.27	0.2
Cr mg L^{-1}	ND	ND	0.04	ND	0.0004	ND	ND	0.018	0.0009	0.012	0.05

ND: not detected

The concentrations of some anions and heavy metals are decreased in the sample 4 due to the dilution process during the water flow.

High values detected for some heavy metals in water like nickel, manganese, iron, lead and chromium present a high environmental risk as they can enter in the food chain and cause adverse impacts on human health, therefore is needed a purification process of the water.

The landfill leacheates samples present sludge and the results of analysis show high values of conductivity (6830 μs/cm), nitrogen (641 mg N L^{-1}), ammonia (569 mg L^{-1}) and chlorine (850 mg L^{-1}). As well, high content of heavy metals were found as manganese (0.906 mg L^{-1}), lead (0.018 mg L^{-1}) chromium (0.320 mg L^{-1}), copper (0.019 mg L^{-1}) and zinc (0.32 mg L^{-1}). These high values could be explained as the samples were collected directly under the landfill without any treatment and dilution process.

4. Conclusions

The concentrations of the air gas-phase pollutants, the solid particles and PM_{10} before remediation process of the landfill show high pollution levels comparing with Albanian and EU standards [6, 8]. The high content of these components in air were due to the open burning process of the solid wastes and anaerobic microbial degradation of organic compounds. The resultant cloud of air pollution, including extremely harmful toxic substances, had a long-term effect on habitants living around the Sharra landfill and the western part of Tirana city. After the remediation process and the implementation of new management method for wastes, the obtained results from this study show an improvement of the air quality and the values of selected indicators resulted to be in accordance with the air quality standards of Albania and EU. Whereas, the results from water analysis showed a contamination of the water as a results of spills coming from the landfill leacheates directly into the Sharra stream which joins the Erzen River. Thus the contamination of surface waters in the area becomes of high concern [2, 7]. Therefore, there is a need for the collection and purification of landfill leacheates, and in addition for the construction of bio-barriers which enhance remediation as the groundwater moves through the treatment zone [13].

As a conclusion the results show the need for the remediation of contaminated site and the application of new technologies for the management of wastes.

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