SOLID WASTE MANAGEMENT FOR SURFACE WATER QUALITY PROTECTION

Laura Kusari

Department of Hydrotechnics, Faculty of Civil Engineering and Architecture, University of Prishtina "Hasan Prishtina", Prishtina, Kosovo

Corresponding author e-mail: laura.kusari@uni-pr.edu

Abstract

Maintaining a good surface water quality is a challenge for our environment. There are many factors that influence surface water quality and each of them needs to be thoroughly investigated. Amongst many, landfills are representing a major threat as a result of the increased waste generation, mainly due to urbanization and the continuous development. In Kosovo, there are still remains of old municipality damp sites, constructed regional sanitary landfills as well as illegal waste disposal sites. There are also industrial waste disposal sites, agricultural waste and demolition wastes, too. This study aimed at the evaluation of the waste generation and characteristics of waste in Kosovo based on the published information. The combination of methods are used to present the solid waste management for the surface water quality protection. Existing data on waste in Kosovo and the data collected from the literature review were the basis for this research. Followed by the generated waste projection, the impacts of the landfills on the surface water quality were analyzed. Based on the data presented, measures for the protection of surface waters and the use of best management techniques to minimize solid waste impacts are presented. Also, waste management options to optimize and reduce waste generation are given in the conclusion.

Keywords*: environment, landfill, surface water quality, waste disposal*

Introduction

Being a new developing country provides many opportunities for further development in all aspects of life. Unfortunately, the recent and future developments are imposing also many challenges, mostly regarding the environmental issues. Kosovo faces many environmental problems regarding the pollution of air, water and soil. Amongst many environmental risk factors the water pollution is the leading one. The surface waters are serving as collectors of all kind of wastes discharged directly onto. The untreated waste waters and the waters from solid waste disposal sites are carrying many pollutants discharged into surface waters. At the same time, those surface waters are transmitting pollutants directly to groundwater body, thus contributing to their pollution, too. Therefore, the aim of this study is to identify the possible threats to surface waters, from the waste

DOI: 10.6092/issn.2281-4485/7886

disposal sites. As noted by many researchers, the growth of urban population and rapid increase in solid waste generation has emerged as one of the main pressing issues of human society; especially in developing countries (Markandya, 2004; Marques et al., 2012). Population growth is responsible for continuous increased water demand, which puts enormous stress in our natural resources. The inadequate disposal of solid wastes causes air, soil and water pollution and is a threat to human health. Furthermore, the industrialization, agricultural activities and many anthropogenic deeds have resulted in an increase demand for water but at the same time there is an increase flow of contaminants into water bodies (Holt, 2000). At the same time, as a result, there is an increased amount of polluted water, as well as the increased amount of generated solid waste. Over the period (1948-2006) the population number in Kosovo has increased by 188, 50% (Ministry of Environment and Spatial Planning, 2009). While the urban population only, for the same time period has increased by 1430.80%. This rate of population growth imposes a higher need for the use of natural resources and as the result there is a higher rate of the generated waste. The annual amount of waste per capita, in the state level, for the 2009 was 729 kg/cap/year. Studies conducted in this field, indicate that higher amount of the municipal waste only in the developing countries is generated from households, with (55-80) % of the total waste amount (Nabegu, 2017; Nagabooshnam., 2011; Okot-Okumu., 2012). According to the same studies, (10-30)% of the rest of the wastes is generated from commercial or market areas. Many researches in this field have identified the factors that influence the generation of waste. Amongst them, Sujauddin et al, (2008) have noted that the municipal waste generation is influenced by family size, their education level and monthly income (Guerrero et al., 2013). But, the amount of generated waste per person is expected to increase even more in urban areas. If we calculate only municipal waste, in 2015, generated amount of municipal waste per capita, in Kosovo level was 177kg/cap/year (0.48kg/cap/day). In capital city Prishtina region this value reached up to 214 kg/cap/year, if expressed daily it is 0.59 kg/cap/day (Kosovo Agency of Statistics, 2016). During the 2015 year, the total amount of municipal waste collected throughout Kosovo was 319,034 tons. This amount of waste is collected, transported and disposed into sanitary landfills. Due to the lack of waste separation and classification system, all the household waste is deposited in the same landfill. In a landfill, when any kind of liquid, in our case water is in contact with municipal waste then leachate is produced. While water percolates through, it leaches materials from waste. During this process, organic wastes degrade to more simple compounds that are soluble. At the same time, soluble inorganic compounds are dissolved. This is an ongoing process that causes water to percolate through the landfill and as a result much polluted liquid is created. This liquid, the leachate changes its color from light brown to black and has a pollution which can be 10 to 100 times that of a raw sewage. The leachate produced from the landfill site is heavily contaminated and consists of a complex wastewater that is very difficult to deal with (Umar et al., 2010). The characteristics of leachate are highly variable depending on the waste composition, amount of precipitation, site

hydrology, waste compaction, sampling procedures and interaction of leachate with the environment (Umar et al., 2010). As a result, a combination of pollutants, very often in high concentrations can deteriorate the surface and ground water quality. The deterioration of surface water quality due to improper waste disposal, is documented by the changes of chemical, physical and organoleptic properties of water (Alemayehu, 2001). Therefore, managing solid waste is an ongoing challenge in order to protect our surface waters. Also, as suggested by Ekere et al. (2009) the involvement of the population in active environment organization is necessary to have better systems.

Materials and methods

In order to develop a successful waste management program we must rely on the existing data on waste. Researchers have noted that only reliable waste management data provides an all inclusive resource for the critical evaluation of waste management options, in all waste management programs (Miezah et al., 2015; Hanc et al., 2011). Unfortunately, we are facing the lack of fundamental statistics on the waste data that can be collected from different sources and are very often inconsistent. Therefore, in this research we will try to gather and provide the needed data on the waste quantity, which will serve as a basis for the future waste management strategies. According to the Law on Waste (Law No.04/L-060), there are three main waste types: municipal waste, commercial waste and industrial waste. The industrial waste is generated mainly from the power plant industry and mining activities; ash waste comprises most of it. It is hazardous waste produced in higher amounts (and located mostly in the central–east part of Kosovo). Two power plants produce yearly about one million tons ashes a year, about 70% of which are disposed in an ash landfill, while the rest gets disposed into air (Ministry of Environment and Spatial Planning, 2009). Medical waste is also considered very hazardous, since both the human health and environment are threatened by it. Although main hospital centers in Kosovo are equipped with incinerators, still only (20-30)% of medical wastes is incinerated. There is also demolition waste (which unfortunately does not have a proper disposal and usually is mixed with urban wastes), end of life vehicles, used tires, etc. Many human activities are responsible for the generation of municipal wastes. Regarding this, about 42% of Kosovo population is provided with the waste collection service (Ministry of Environment and Spatial Planning, 2009). This rate was highest in the Prishtina region where it reached up to 64%, in the 2007 year. In the state level, the waste collection service is provided to 90% of the population living on urban areas, while in the rural areas it covers only 10% of the population. The sanitary landfills, responsible for the collection of municipal solid wastes are operating in 6 major cities in Kosovo (Prishtine, Peje, Prizren, Mitrovice, Gjilan and Ferizaj).

Municipal waste landfill of the Prishtina region (Fig. 1) operates since the 2005 year and is located in the Mirash, the municipality of Obiliq. The municipal waste

DOI: 10.6092/issn.2281-4485/7886

landfill is situated at the western side of Prishtina, with the coordinates 42.666952° latitude and 21.061636° longitude, as shown in the figure 1.

.

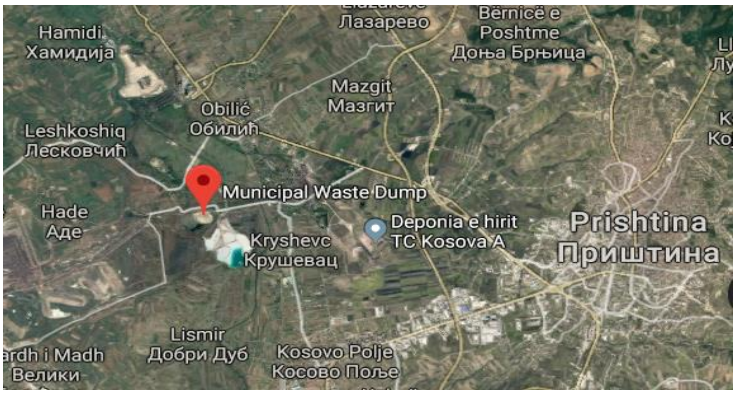

Figure 1
Location of the sanitary landfill, Prishtina

This landfill covers a surface area of about 40.0 ha and besides the Prishtina municipality serves also the municipality of Obiliq, Lypjan, Fushe Kosove and Drenas. It has a monthly capacity of 6000 t and the total capacity of 3. 500 000 m^2 (Fig. 2). The population in this area is 892,506 inhabitants.

Figure 2
Sanitary landfill in Prishtina

In order to have an insight into waste projection for the incoming years, we must know the waste quantity generated in present. As explained earlier, the growth rate of population shows an increased trend as well as the growth rate of population in urbanized areas.

For this reason, it seems a more acceptable and precise way is to try and calculate the generated waste projection based on the population number.

The landfill in Prishtina has the highest rate of disposal waste. Its rate was 83,742.23 tons in 2010, with an increase to 106,119.00 tons in the 2015 year. The increased amount of waste disposal in Prishtina landfill, for 7 years in a row, is presented in the table 1.

Municipal waste is one of the main factors contributing to the overall waste amount in Kosovo, and particularly in Prishtina. There is an increase of generated amount of household waste per capita, in Kosovo and particularly in Prishtina region where it reaches up to 214 kg/cap/year, if expressed daily it is 0.59 kg/cap/day (Kosovo Agency of Statistics, 2016).

Year	Disposed waste quantity (t/year)
2009	84,660.59
2010	83,742.23
2011	81,816.63
2012	78,393.54
2013	89,806.18
2014	88,803.29
2015	106,119.00

Table1
Quantity of waste disposal in Prishtina landfill

The waste composition structure in Prishtina landfill, is presented in the following table (table 2). As it can be noticed, the biodegradable waste and paper accounts for as much as 53.8 % of the total waste.

Nr	Waste structure	Percentage (%)
1	Hazardous waste	0.40
2	Wood	1.20
3	Metal	1.20
4	Textile	3.50
5	Glass	4.50
6	Inert	7.20
7	Other	7.60
8	Paper	12.80
9	Plastics	14.80
10	Biodegradable	41.00
11	Other	5.80

Table 2
Municipal waste composition structure, Prishtina landfill

The heterogeneity of the waste makes it harder to be reused as a raw material. To improve this, the separation of wastes in its source and its sorting would be the first step in waste management strategy.

Except for the municipal waste, there are also about 580,154 tones of industrial waste (from which 36,241 are hazardous wastes). Unfortunately, we do not have data on the demolition waste, even though due to many rebuilding and construction it has a considerable impact on environment issues. This landfill's environmental impacts are bigger taking into account the medical waste, 138,494.3 tons (2013) in Prishtina only. All those wastes are deposited in Prishtina sanitary landfill, but its condition is not satisfying due to the poor maintenance. It is evident the waste water leakage from the landfill, contributing to the deterioration of surface and ground water pollution. To make things even worse, there are more than 400 illegal sanitary landfills, with total area of 301.18 ha, many of which are in the Lypjan municipality.

It is known that landfills tend to impact the surface waters, in the aspect of their quantity as well as their quality. Those impacts do change during the phases of landfill construction, operation, or the final phase, known as landfill closure phase. The main factor contributing to the waste quantity and its quality in Kosovo is the lack of separation and classification system, so at the same landfill there are many

DOI: 10.6092/issn.2281-4485/7886

type of wastes disposed (Table 2). This further contributes to the low rate of waste treatment and consequently to the higher rate of the environmental pollution. Mismanagement of constructed landfills, in their operation phase is a factor contributing to environmental pollution. The Mirash landfill, as mentioned earlier is the case where mismanagement causes negative impacts on environment. Since the landfill is already constructed and is operating, the main impacts of this landfill operation on surface water is the leakage from the landfill (where the disposal of municipal waste is often combined with disposal of other types of waste) as well as the release of uncontrolled discharges of surface runoff from the landfill site. There is also the landfill's impact on groundwater that needs to be investigated thoroughly. The landfill operation can cause the decrease of the surface waters infiltration rate to groundwater. This may be as a result of artificial surfaces in and near the constructed landfill and as a result of the designed drainage system. Also, leakage of leachate from landfill can contaminate ground waters in the vicinity. To make things even worse, many open surface landfills operating in Kosovo are often in the vicinity of residential areas and surface waters. For example in Lypjan, the distance of the landfill from the river is as close as (10-20) m. Therefore, those landfills are a permanent risk to our environment throughout the country.

Mirash landfill shows many problems in its operation. What is important for this area of research is that during a site visit, some pond (wetlands) created in its vicinity were noticed. Those ponds drain the leakages from the landfill and may come in direct contact with surface and ground waters; the pollution is then inevitable. The illegal dump sites throughout this area where the waste is disposed without any control are another concern. Those illegal dump sites are very often in the vicinity of river courses. Their impact on surface waters must be studied thoroughly, since they represent even a higher environmental risk.

Results and Discussion

The focus of this research was to assess the likely impacts of sanitary and illegal landfills on surface water quality. Researchers have suggested that the factors affecting the environmental aspect of solid waste management in developing countries are the lack of environmental control systems and the evaluation of the real impacts (Asase et al., 2009). At the present, the routine of monitoring surface water quality in Kosovo is conducted by Hydro Meteorological Institute, through the monitoring network consisting of 54 sampling locations. Currently, there are only 10 physical parameters monitored for 11times/year. For the area of concern, regarding the landfill's impact on the quality of surface waters we can only rely on the temporal river quality data measured at the Hydro Meteorological station. In the vicinity of the operating Prishtina landfill (Mirash), is the Sitnica River, which after passing Mirash, reaches Obilic, Vushtri and finally Mitrovica where it becomes a tributary of Iber River. Sitnica River is the most polluted river in this area, as it receives both the municipal and industrial waste waters. The results of laboratory exams have indicated the following water quality parameters (Ministry of Environment and Spatial Planning, 2015). The physical-chemical analyses show

an increase of the suspended material, even above the maximum allowance value. As for the dissolved oxygen, its value varies a lot depending on the time of sampling. It value can be from 6. 20 mg/l to as low as no oxygen at all (at some sampling seasons). Regarding the Biological Oxygen Demand (BOD_5), it usually ranges from 14.18 mg/l to 19.67 mg/l, depending on the season. This shows that surface water contains little or no organic contamination from the landfill site. Electrical conductivity is the indicator of the presence of the dissolved inorganic ions in the water. Electrical conductivity, in this area is in the range from (1522 – 1616) μS/cm. The high values of EC measured in this station are the indicators of the landfill site's effect on surface waters. The value of pH at the same sampling station varies from 7.96 to 8.36 which are in the range of World Health Organization's standards. The measurement of phosphates has indicated a value from 0.771mg/l. Both Ammonia and Nitrogen-Nitrates show value as high 6.237mg/l, respectively 2.614 mg/l. The high level of ammonia and nitrates indicates that the surface water quality is affected by the leachate from the landfill site. In the lack of analysis of the quality and quantity of leachate from landfill, we have compared the surface water quality parameters and noticed an increase of many of them. From these results, we can notice that almost all measured parameters, except for DO are relatively high, indicating leakages from Mirash landfill. Since landfill leachate is usually characterized with high concentrations of Ammonia, BOD_5 and COD, it can be observed from the given results that the water quality of this stream is relatively polluted as a result from landfills operation. The findings that indicate the deterioration of surface water quality due to landfill's operation are consistent with many other research's conducted in this field (Hossain, et al., 2014; El-Salam et al., 2015).

To prevent further deterioration of surface waters, we should aim at the decrease of waste quantity, which can be achieved through waste separation and recycling. Some efforts are already done in some places in Kosovo, through plastic recycling (in Mitrovice and Rahovec), paper collection, glass bottles reuse and different metals. So, recycling, reusing and composting of wastes should be a priority. Next, we need to apply some mitigation measures during the landfill operation and make sure to contain and control the contaminated water generated at the landfill site. This means, that it is required the total containment of a site, be it a landfill or an illegal dump site.

The leakage from the landfill should be managed in order to prevent the pollution of adjacent surface waters. The prior measures should aim at the reduction of the leakage production by reducing the amount of precipitation coming in contact with wastes, preventing the surface runoff come to contact with disposed wastes and control of the disposed liquids in the landfill. After the leakage reduction, next measure should aim at the containment of the leachate within the operating landfill, last one preferably at the geological formations that are able to attenuate the leachate. And finally, the leachate collected should be contained and treated within lagoons, until it has an adequate quality to be discharged to the surface waters. As

DOI: 10.6092/issn.2281-4485/7886

for the protection of groundwater, which impacts the quality of surface waters too, the prevention from spillages and leaks can be achieved through the use of engineered drainage systems and application of low permeability surfaces (Clark, 1996).

Conclusions

The actual state of waste in Kosovo is experiencing some weaknesses regarding the collection, separation and reuse of wastes. The system of solid waste management is uncoordinated and there is data missing for the generation, collection, separation and waste treatment. The performance of constructed landfills is not according to designed standards and there is a high number of dump sites throughout Kosovo. In many cases, those are adjacent to streams and thus contribute to the deterioration of surface water quality. Therefore, the better management of the waste disposal sites is needed, in order to reduce its negative impacts to adjacent streams.

In order to prevent river's pollution, it is of a great importance to control the leachate quantity as well as its quality and aim to comply with international standards on the discharge criteria into natural streams.

The development of waste strategies and waste management plans should be encouraged at local and central level. Waste strategies in the future should focus on the development of the waste infrastructure and the strengthening of the inter institutional cooperation in the waste sector. Continuous improvement of human resources through education and awareness rising in the universities and research institutions, towards preparing professionals in the fields of environmental engineering should be a priority.

In order to reduce the amount of generated waste per capita, the recycling of wastes should be planned and reinforced. The heterogeneity of the waste makes it even harder for it to be reused as a raw material. To improve this, the separation of wastes in its source and its sorting would be the first step in waste management strategy. The recycling in Kosovo has a long way to go and it has to be planned properly, by the engagement of both, private and public sector. Also, the new alternative technology for managing waste has to be analyzed and taken into account. And finally, as a part of solid waste management plan the landfill monitoring program should be incorporated with quality assurance control, leachate, surface and ground water monitoring. Finally, the routing reporting should be encouraged through annual environmental reports.

References

ALEMAYEHU T. (2001) The Impact of Uncontrolled Waste Disposal on Surface Water Quality in Addis Abbaba, Ethiopia. Ethiopian Journal of Science, 24(1):93-104. Doi: 10.4314/sinet.v24i1.18177

ASASE M., YANFUL E.K., MENSAH M., STANFORD J., AMPONSAH S. (2009) Comparison of Municipal Solid Waste Management Systems in Canada and Ghana: A Case Study of the Cities of London, Ontario and Kumasi, Ghana. Journal of Waste Management, 29(10):2779-2786. Doi: 10.1016/j.wasman.2009.06.019.

CLARK J. (1996) Rivers and their Catchments: Impacts of Landfill on Water Quality (Information and advisory note) Earth sciences Branch. Scottish Natural Heritage, Edinburgh http://www.snh.org.uk/publications/on-line/advisorynotes/39/39.htm

EKERE W., MUGISHA J., DRAKE L. (2009) Factors Influencing Waste Separation and Utilization among Households in the Lake VictoriaCrescent, Uganda. Journal of Waste Management, 29(12):3047-3051. Doi: 10.1016/j.wasman.2009.08.001.

EL-SALAM M. M., ABU-ZUID G.I. (2015) Impact of Landfill Leachate on the Groundwater Quality: A Case Study in Egypt. Journal of Advanced Research, 6(4):579-586. Doi: 10.1016/j.jare.2014.02.003

GUERRERO L.A., MAAS G., HOGLAND W. (2013) Solid Waste Management challenges for Cities in Developing Countries. Waste Management, 33(1):220-232. Doi: 10. 1016/j.wasman.2012.09.008

HANC A., NOVAK P., DVORAK M., HABART J., SVEHLA P. (2011) Composition and Parameters of Household Bio-Waste in Four Seasons. Waste Management Journal. 31(7): 1450-1460. Doi:10.1016/j.wasman.2011.02.016.

HOLT M.S. (2000) Sources of Chemical Contaminants and Routes into the Fresh Water Environment. Food and Chemical Toxicology. An International Journal, 38(1):21-27. Doi:10.1016/S0278-6915(99)00136-2

HOSSAIN L., DAS S. R., HOSSAIN M. (2014) Impact of Landfill Leachate on Surface and Ground Water Quality. Journal of Environmental Science and Technology, 7(6):337-346. Doi: 10.3923/jest.2014.337.346

KOSOVO AGENCY OF STATISTICS (2016). Series 2: Agriculture and Environment Series. Municipal Waste Survey, MWS 2015.

MARKANDYA A. (2004) Water Quality Issues in Developing Countries. World Bank and University of Bath. Contribution to a Volume in Essays in Environment and Development. J.Stiglitz (ed.). Final Draft. Initiative for Policy Dialogue (IPD)

MARQUES R.F.P.V., DA SILVA A.M., RODRIGUES L., COELHO G. (2012) Impacts of Urban Solid Wa.ste Disposal on the Quality of Surface Water in three Cities of Minas Gerais-Brazil. Agricultural Engineering, 36(6). Doi:10.1590/S1413-70542012000600010

MIEZAH K., OBIRI-DANSO K., KADAR Z., FEI-BAFFOE B., MENSAH M. (2015) Municipal Solid Waste Characterization an Quantification as a Measure Towards Effective Waste Management in Ghana. Waste Management Journal, 46:15-27. Doi: 10.1016/ j.wasman.2015.09.009

MINISTRY OF ENVIRONMENT AND SPATIAL PLANNING (2009) Kosovo Environmental Protection Agency. The State of Waste in Kosovo 2008, Report.

MINISTRY OF ENVIRONMENT AND SPATIAL PLANNING (2015) Kosovo Environmental Protection Agency. Report on the State of Waters in the Republic of Kosovo.https://www.ammk-rks.net/repository/docs/Raporti_i_ujrave_i_2015_shqip_(2).pdf

NABEGU A. (2017) An Analyses of Municipal Solid Waste in Kano Metropolis. Nigeria. Journal of Human Ecology, 31 (2): 111-119. Doi: 10.1080/09709274.2010.11906301

NAGABOOSHNAM J. K. (2011) Solid Waste Generation and Composition in Gaborone, Botswana, Potential for Resorce Recovery. Master Thesis. Energy and Environmental Engineeing, Linkoping University, Sweden. https://www.diva-portal.org/smash/get/diva2: 488964/FULLTEXT01.pdf

OKOT-OKUMU J. (2012) Solid Waste Mangement in African Cities-East Africa. Waste Management-An Integrated Vison. In tech. Doi: 10.5772/50241 ISBN: 978-953-51-0795-8

DOI: 10.6092/issn.2281-4485/7886

SUJAUDDIN M., HUDA M.S., RAFIQUL HOQUE A.T.M. (2008) Household Solid Waste Characteristics and Management in Chittagong, Bangladesh. Journal of Waste Management, 28 (9):1688-95. Doi: 10.1016/j.wasman.2007.06.013

UMAR M., AZIZ H., YUSOFF M. (2010) Variability of Parameters Involved in Leachate Pollution Index and Determination of LPI from Four Landfills in Malaysia. International Journal of Chemical Engineering, Vol. 2010, ID 747953. Doi: 10.1155/2010/747953