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ATMOSPHERIC DISPERSION OF RESUSPENDED DUST FROM LANDFILL A MODELING APPROACH

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Abstract: Data on dust resuspension from solid waste landfills are unavailable in transition countries. Due the complex dust composition, its resuspension could cause serious health effect on surrounding inhabitants. In this paper, influence of resuspended dust from solid waste landfill in medium side city in Serbia on surrounding were modeled. Emission factor for dust resuspension were calculated according to the resent research and dispersion in air were simulated using ADMS Urban modeling software. According to the obtained results, modeled concentration in selected receptors were below limit values for dust defined by EU Directives. Even though simulation could be starting point for indication of pollution levels, systematic measurement around landfill is imperative in Serbia.
Keywords: air pollution, dust, air dispersion, modelling

INTRODUCTION

Air pollution is one of the main factors that have negative influence on quality of life and health of population in urban areas. Exposure to the air pollution could have fatal consequences and according to the World Health Organisation (WHO) it causes premature death for a 4,2 million people every year all over the world (WHO 2021). Air pollution causes cardiovascular, various respiratory disease and lung cancer, and it is the main issue in solid waste management, especially in developing countries where landfilling on uncontrolled dumps is dominant waste treatment. This waste management practice implies negative environment impacts like odours, dust, noise, groundwater pollution and greenhouse gas emission. Although the dust emission from landfills intensively occupies attention of the scientific community and the decision makers because of its complexity and potential strong influence on human health, this pollution phenomenon is not explored enough (Di Felice P, 2014; Han et al., 2014).

Information on chemical composition of resuspended particles, especially qualitative and quantitative heavy metal content is crucial because of it's negative health effects. Research provided in Malesia analysed connection between respiratory symptoms at children's with the dust resuspended from solid waste landfill (Esphylin et al., 2018). In resent studies, provided in Indonesian city of Semarang, total suspended particles as well as heavy metal content (Pb i Zn) originated from landfill were investigated . Samples analysis revealed concentration of Pb below limit value (0,84–1,78 μg/m^3). Detected Zn concentration were from 7,87 do 8,76 μg/m^3 but limit value is not defined by Indonesian low (Budihardjo et al., 2018). Also, the influence of heavy metal were analysed at different distances from two landfills in Egypt. Concentration of some metals (Cd, Cu, Ni, Cr i Zn) in ambient air samples were the highest at the sampling sites near the landfills reducing with the distance from the landfills (Rashad M and Shalaby E A, 2007). Study provided at the landfill located at the Crete had a goal to determinate the exposure of landfill workers to the fugitive dust emission and consequently to the heavy metals like Cr, Mn, Zn, Ti i Pb. Results indicated that presence of heavy metals in human tissue is related to the high heavy metals concentration in landfill dust (Chalvatzaki et al., 2015). High concentration of heavy metals causes respiratory i cardiovascular issues at male landfill employee (Chalvatzaki et al., 2014). High influence of landfill on environment is also confirmed in research provided in United Kingdom, where the heavy metal content in particulates (PM10 and PM2.5) from landfill were analysed. Comparing heavy metals content in samples from landfill with samples from urban areas showed higher concentration of Fe and Pb in landfill samples (Koshy et al., 2009).

In transition countries, like in Republic of Serbia, there are no reliable data on any emission from landfill. Since fugitive dust emission or dust resuspension from landfill were not investigated at all, a comprehensive data gathering could be useful for modelling methods like one of the approved methods that could give an indicative pollution level. Regarding the fact that there are no data on concertation of particles originating from the landfills due to the wind resuspension, in this paper emission rate as well as dust dispersion in ambient air will be modelled.

METHODOLOGY – MODELLING METHODS

When there are no measuring data, modelling methods could be useful tool for reaching indicative levels of pollution concentrations. In this paper the simulation was carried out using Gaussian dispersion model: The Atmospheric Dispersion Modelling System software (ADMS) which is developed by the consulting company "Cambridge Environmental Experts Consultants" (CERC). ADMS is one of the widely used dispersion models which simulate a wide range of pollution from various sources. However, ADMS Urban is data demanding software that requires data of emission source (physical characteristics and emission rate) and surrounding environment (meteorological condition and terrain configuration) as well (CERC, 2001).

RESULTS AND DISCUSSION

— Source of emission

The landfill site of city of Zrenjanin covers an area of 6,71 ha. Waste from the city and surrounding settlements (123 362 people are covered) are disposed at this landfill. The dump contains cca. 268.400m^3 of mostly of communal waste, waste from construction sites and non–hazardous medical waste (RPWM, 2011). The average waste height is 4m and the modelled annual weight of the disposed is 42 116 tons per year (Vujic et al., 2009). Landfill is partly fenced. Waste is mixed with the soil and periodically is covered with inert material. The source is defined as the area type like it is defined in *Air Quality Modelling Guidelines* (Air Permits Division Texas, 2014). Landfill is graphically represented with the help of the ADMS Mapper program. The graphical segment of the landfill presents a real environment of the simulation (Figure 1). In general, landfill is situated south–west of the city, on the 5km distance from the city centre and 1,7km from the nearest houses (Figure 1).

Figure 1. Research area, landfill in Zrenjanin

— Meteorological conditions

Data for air dispersion modelling include two sets of meteorological data:

1. Required parameters: Wind speed (m/s) and wind direction (°) and parameters related to the sensitive surface flux: year/day/time/cloud cover or urface flux (W/m^2)
2. Additional meteorological data: Boundary layer height (m), Surface temperature (°C), lateral spread (°), relative humidity (%)

The meteorological parameters used in this paper included summer period (June and July of 2021), period with the low precipitation. Dominant wind direction in the selected period were north–west (NW) and south–east (SE) (Figure 2). Average temperature during this period were 26ºC (maximum 38 ºC, and minimum 12 ºC). Average cloud cover were 3 octas.

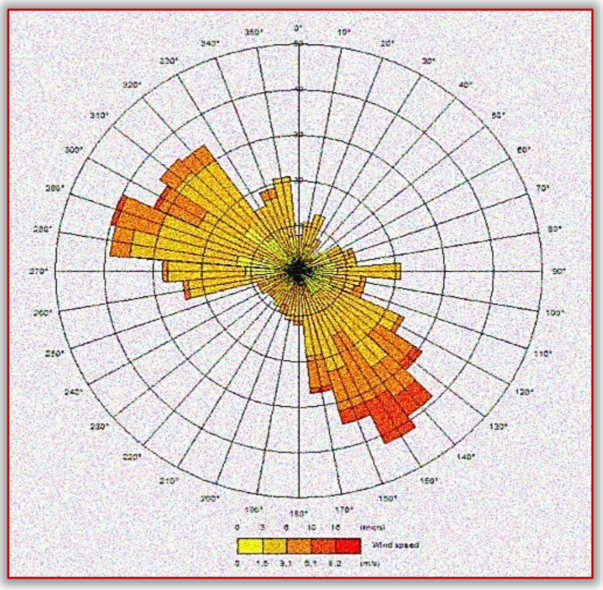

Figure 2. Wind rose for the period of June and July of 2021

— Emission rate

Dust resuspension depends on landfill area covered with soil, type of the roads (paved or no paved), number and weight of the truck that operates on daily basis, meteorological data: prevailing wind speed and relative air humidity. For this research, to define the landfill dust resuspension an emission factor was calculated according to the methodology described in Yu–Jin (2008). For fraction emission flux (F in g cm^{-2} s,) reduction factor (R) for barren land of 0.1, average wind speed (u_z) at reference height *of 10m of 277cm/s,* von Kármán constant (k) of 0,4 and surface roughness length (z_0) for barren land of 1cm were used.

— Terrain configuration

For the modelling of propagation of methane from landfills, surface roughness of 1m which is typical for cities and woodlands is used in this paper.

— Sensitive receptors

To specify landfill influence on surrounding area, a few sensitive receptors were selected (Table 1). The receptors were selected according to its vulnerability, location, and distance from the landfill and regarding the dominants wind direction as well. Hence, the nearest houses (Houses 1, Houses 2 and Ranch), as well as City beach that is very crowded during the summer period.

Table 1– Senzitive receptors caracteristics

Receptor name	Coordinates		Receptor height (m)	Distance from landfill (m)
Houses1	449231.88	5024825.50	1.50	2700
Ranch	448696.50	5024005.00	1.50	2250
City beach	451682.16	5022156.50	1.50	1500
Houses2	450917.62	5024044.00	1.50	1700

— Dust dispersion and concentration levels

According to the results obtained using the meteorological data for the whole period of June–July 2021 (Scenario S1), particulate concentration was the highest at the landfill itself, reaching concentration of 377 μg/m^3. Since the World Health

Organization defines daily limit values for total suspended particles of 120 μg/m³ (WHO 2005), while EU defines 150 μg/m³ (EU Council Directive 80/779/EEC) modelled concentration in surrounding area (sensitive points) were lower and the intensity of landfill influence is very low (Table 2).

Figure 3. Modelled concentration in surrounding area (sensitive points)

Table 2–Modeled dust concentrations in different scenarios

Receptor name	Dust concentration in different scenarios (μg/m3)		
	S1	S2	S3
Houses1	2	0	1
Ranc	3	0	4
Landfill	377	148	92
City beach	8	6	0
Houses2	1	0	0

Furthermore, to identify most unfavourable condition, detailed analysis of meteorological data was provided. Hence, two scenarios for modelling were selected:

≡ S2–hot days (32ºC) days with SE wind direction reaching the speed of maximum 7m/s, with very high could cover (Cl=7 octas).
≡ S3–days with lower air temperature (24ºC) with dominant NW wind direction reaching maximum wind speed of 5m/s, with moderate cloud cover (Cl=5octas).

The two scenarios were processed and modeled concentration of particles in ambient air for the sensitive receptors were obtained (Table 2). These concentrations indicate that particles from landfill were highest at the landfill itself, and the sensitive receptors remained with no significant influence of landfill.

Although, the results indicated minor influence of landfill on surrounding area, it should be investigated furthermore by considering more reliable emission factors for dust resuspension, data on landfill infrastructure and maintaining and operating practice on landfill. However, monitoring data should be most desirable for this kind of research.

CONCLUSION

Even the huge number of landfills in Serbia are in the vicinity of settlements jeopardizing environment and population health, in general there no practice of air quality monitoring near these emission sources. In these situations, modelling of emission rate and atmosphere dispersion could be useful to indicate potential pollution concentration and most endangered areas.

However, by Serbian low, the recommended method for air pollution modeling is not defined, but deviation between modeled and measured concentration is allowed to be 50%. Hence, in this paper the emission rate of particulates was calculated and modelling of dust resuspension from landfill and its dispersion in the atmosphere were performed. Results indicated that modeled concentration were very high at landfill itself reaching concentrations higher than limit value, but very low at the selected sensitive receptor that are close to the landfill. This could be starting point for establishing continual monitoring of air quality in area surrounding the landfill.

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