

Adverse impact of municipal solid waste transportation on collected stormwater biosolids quality

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Abstract. The objective of this paper was to identify possible specific contamination of stormwater biosolids, with a special emphasis on pollution associated with transportation of municipal solid wastes to the waste utilization plant. The study area for sampling includes two selected points of separate stormwater collection system in Cracow. Samples of stormwater and biosolids were collected during spring-summer-autumn season addressed towards rainy days to check the scope of the problem. The results led to conclusion, whether the waste utilization plant impacts the stormwater quality, compared to the high-traffic road. The largest pollutants found in stormwater near the plant were nutrients (nitrogen, phosphorus) however general content of organic matter in biosolids collected in separated stormwater system also confirmed adverse impact of solid waste transportation on stormwater sludge (biosolids) quality.

1 Introduction

Constant increase of impervious land cover in municipal areas during the last few decades has led to the increase in stormwater volume to be handled by municipalities. The water quality of this runoff depends on numerous factors which are locally specific. The range of pollutants include: the layout of drainage infrastructure, road and building materials used, the range of transport systems and traffic density, the percentage of impervious surfaces, human behaviour, and waste disposal practices. The most important traffic-related pollutants are emissions and abrasion wear products, which can be categorized as following: exhaust emissions, fuel and lubrication, leakages, vehicle component wear, and pavement wear. Common stormwater pollutants originating from anthropogenic practices include hydrocarbons and surfactants, metals, insecticides, herbicides, pharmaceuticals and personal care products, organic matter, nutrients, sewage, and litter [1-2]. In addition, sediments originating from anthropogenic activities bind with pollutants and act as a mobile substrate in transport of these pollutants into receiving waters. Thus stormwater collected mainly from street gullet is bacterially contaminated, but

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specific pollutants are: suspended particulate matter, polycyclic aromatic hydrocarbons, nutrients [3-6] and rarely pesticides.[5].

In contemporary storm sewers system the majority belongs to the separated sewer system which almost completely replaced the "one pipe system" of the past. Such a system reduces the risk of large quantities of sewage from street runoff entering the surface waters during wet weather, however untreated stormwater runoff still can be a significant source of ambient surface water pollution. Typical technical solution of an entry of stormwater to a sewer system is a street sump (Fig.1. [2] after [1]), where a stormwater stream enters the catch basin and a sump captures sediment, debris, and associated pollutants acting as pre-treatment. The stormwater, partially cleaned is discharged through the submerged outlet pipe to a main sewer pipe located usually under the street or road surface[8-9].

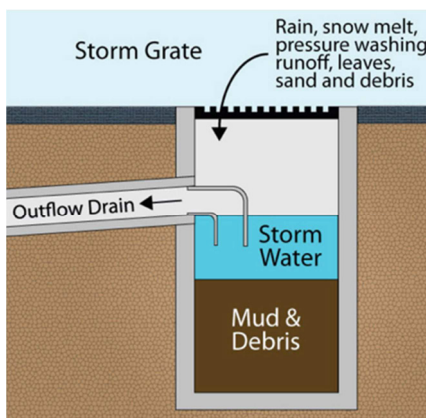


Fig. 1. Design of typical catch basin with sump

As stated above road traffic has significant impact on a stormwater pollution and the paper is focused on specific danger for stormwater quality possible caused by solid waste transportation to a processing point. The problem has been analysed in ! Mil populated City of Krakow (Sothern Poland , EU), but it appears to be common risk for mid-size and large municipalities being related to unavoidable solid waste transportation via city roads. Solid waste production in European municipalities, despite numerous state and regional programs to reduce their quantity (mass) remains on almost constant level, Data published by Eurostat [10] led to the conclusion that the progress with respect to solid waste disposal has been obtained rather by contemporary management (i.e. selection, recirculation, incineration with an energy production) rather than by minimization of municipal solid wastes generation. Table 1 compares trends in municipal sludge management in last 25 years, expressed as per capita values.

Even if material recycling is at present recognized as the best solution of wastes' disposal, undoubtedly an incineration of it seems to me most dynamic way of solid handling, especially in large European cities. At present almost 30% mass of these wastes is being incinerated [8]. Increasing selection of wastes performed by customers led to changes in transportation characteristics of bulk mass of wastes being transported to the incineration plant. Increase of moisture and possible conversion of some fraction of food wastes into liquid phase to be incinerated, caused mainly by elimination of paper from the bulk mass, can be an initial explanation of the problem. Paper describes result of studies performed in Kraków, Poland in year 2019. Tests were initiated due to an operational observation that wastes transporation from remote area of the municipality to the incineration plant suppose to have an adverse impact on stormwater quality.

Table 1. Trends in municipal solid wastes generation per capita in EU-28 (extracted from [8]).

	1995	2000	2005	2010	2015	2016	2017	2018
Landfill	286	262	202	178	127	121	118	117
Incineration	34	84	103	121	127	130	132	131
Material Recycling	54	87	105	125	141	145	147	150
Composting	33	53	59	66	75	81	83	83
Other	60	27	37	13	10	11	11	11
Total	467	513	506	503	480	488	491	492

2 Materials and methods

2.1 Area of investigation

The study area includes two sampling sites located in the city of Krakow, both of the them are catch basins of stormwater sewer system. The catch basin no. 1 (this symbol is used on Figures) is situated directly on the high-traffic transit three lane road in the northwest part of the city. The second one is located on the sole access road to the waste utilization plant in the western part of the city. The most significant difference between these locations is urban land use and its impact on collected samples. Sample point 1 located in northern part of Krakow is mainly exposed to pollution associated with passenger vehicular traffic. However, the road with the catch basin no. 2 is exposed to contamination related to transportation of municipal solid wastes to the plant primarily by heavy-duty dumper trucks. Separately from the particular traffic, there is also a risk of potential leakage of wastes from these trucks, and this possible risk was evaluated in the field test described in the paper.

2.2 Sampling points location's choice

Samples of solid matter accumulated at the sump of catch basins (see Fig.1. above) were collected during half year of tests next day after heavy rains. That ensured that that proper mass and volume of sample were available. Samples of the stormwater were collected simultaneously to perform parallel tests. The samples were taken in accordance with the relevant sampling guidelines given in EN 25667-2 and EN ISO 5667-3. The real frequency of the sampling was once a month in the period from April to July 2019 and from Mid-September to November this year. The sample taking was completed with the assistance of qualified operation personnel of the Cracow Waterworks. The procedure launched with opening the catch basin by removing the grate. To avoid mixing of biosolids with stormwater, stormwater samples were collected first. A water sampling device was gently immersed into the catch basin and then its contents poured into 1-litre glass bottle which served as the stormwater sample container. Subsequently a solid phase (biosolids) from the bottom of the catch basin were grabbed by a device referred to as an extended spoon and placed in 1-litre plastic bottle. In each of the both sampling sites were collected 3 litres of stormwater and 1 litre of biosolids to carry out intended analytical laboratory tests.

2.3 Laboratory procedures

All experiments were carried out in the laboratories of Cracow Waterworks and Cracow University of Technology according to the European Standards established by the European Committee for Standardization. The list of tested physicochemical parameters and used European is shown in Table 2.

Table 2. List of tested parameters in biosolids samples with the associated European Standards

Parameter	Standard
pH	EN ISO 10523:2012
Total Kjeldahl Nitrogen (TKN)	EN 25663:1993
Total Phosphorus (TP)	EN ISO 17025:2005
Total Suspended Solids (TSS)	EN 872: 2005
Chemical Oxygen Demand (COD)	EN ISO 15705:2002

3 Results and discussion

The dry matter content measured in the samples collected near the waste utilization plant (place 2) was slightly lower than in place 1 and the relative difference depended on the date of material collection (see figure 2).

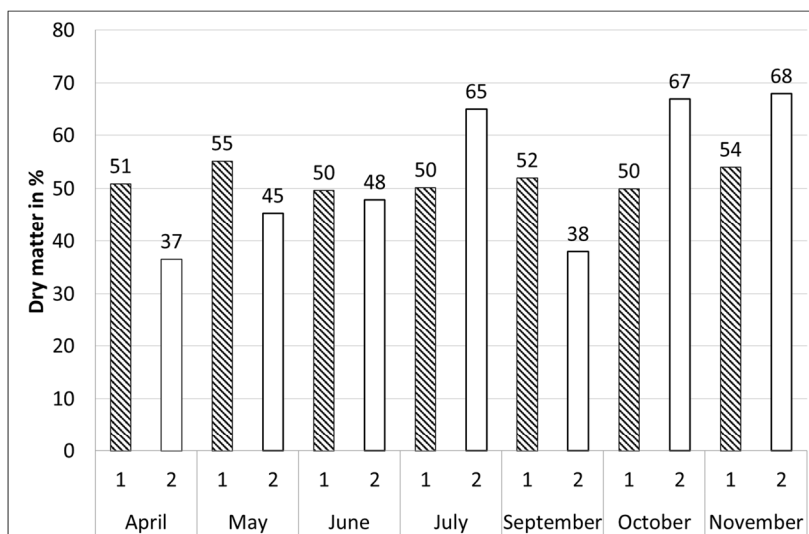


Fig. 2. Dry matter content in samples taken from two locations (explained in the text)

The lowest dry matter value observed was : 50% in place 1 and 37% in place 2 . With the date of subsequent sampling, the dry matter content increased to the highest value of 55% in place 1 and 68% at place 2. I can be found that variation of dry solid content is bigger in sampling point 2 than in sampling point 1. This relationship is presented in Figure 3

Tests on the organic matter content in the samples collected near the waste utilization plant indicated larger values than in place 1 and varied from 14% to 24% of dry matter. This

confirmed the assumption that solid waste transportation may led to increase in organic matter content in biosolids which can be strictly bind with higher contamination of stormwater due to intensive solid waste transportation. Therefore, the cargo traffic to the waste incineration plant resulted in increased organic matter content, as compared with high-traffic road, however the values still not exceed the average of sewage sludge.

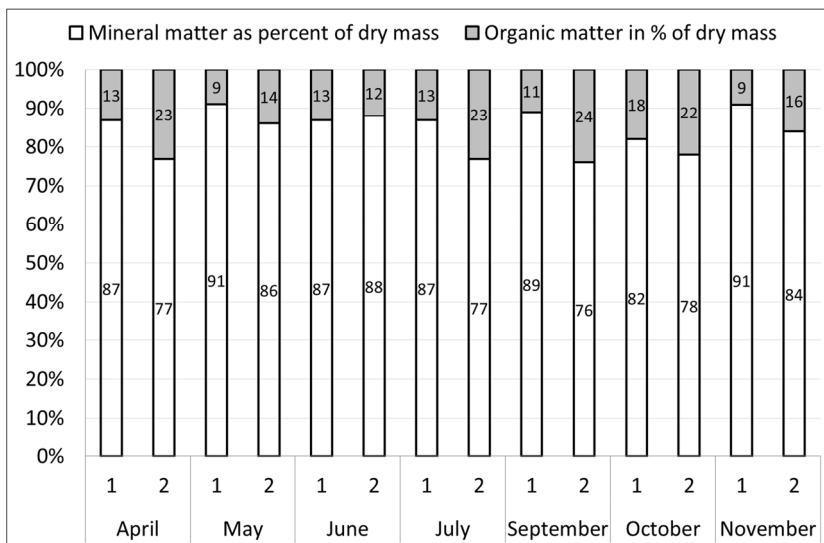


Fig. 3. Structure of solid matter in a biosolids samples taken from two sampling points

Figure 4 presents results of tests on nutrients' concentration represented by TKN and Total Phosphorus. TKN i.e. Total Kjeldahl Nitrogen represents the content of organic and ammoniac nitrogen determined in the sample after mineralization. It does not include nitrate and nitrite nitrogen and not always all organic nitrogen. With respect to TKN value in samples from both places, it can be found, that in all but one (July) samples, this parameter is visibly higher in biosolids from samples grabbed near the solid waste incineration plant. The same relations were proved for total phosphorus whereas the phosphorus content in samples taken in place 2 are almost twice higher than in place 1.

Similarly to observations on solid matter content (Fig 3) it leads to the conclusion that intensive road traffic by specialized trucks for solid waste transportation have adverse impact on biosolids in stormwater sewerage systems.

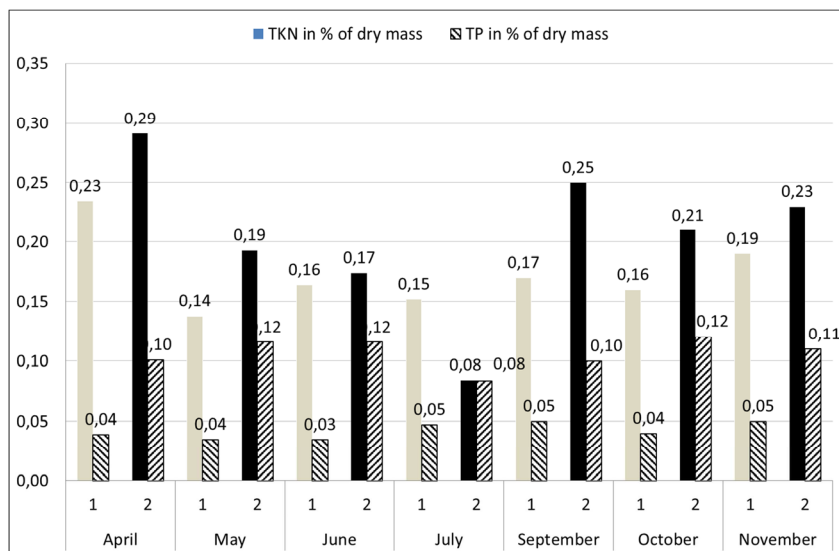


Fig. 4. Results of tests on nutrients' concentration represented by TKN and Total Phosphorus

When comparing samples taken from location point at very heavy traffic by various vehicles (place 1) with less intense traffic caused by waste transportation (place 2) one can see that this specific municipal activity may create significant operational and ecological problem even if transport of solid wastes is being performed by modern specialized trucks. It may be credited to leaking of some decomposed organic matter for example food debris as well as transportation of organic contaminants on trucks' tyres and/or chassis. Further research will be conducted to achieve reproducibility of the results and consider more accurately other factors affecting stormwater quality such as weather condition.

Conclusions

The field sampling of biosolids were withdrawn from the sump at separate sewage system in two specifically selected research proved that in those from the stormwater collection system close to the waste utilization plant showed much higher concentration amounts of the nutrients than samples from housing area, even if traffic intensity was much higher. The source of nutrient pollution in this area could be related with leakage of wastes transported to the plant.

Tests on nutrients and structure of solids' dry mass indicate the adverse impact of heavy-duty trucks on stormwater and biosolids quality near the plant.

Acknowledgement: This research has been supported by EMMAT project E-mobility and sustainable materials and technologies PPI/APM/2018/00027 financed by the Polish National Agency for Academic Exchange (NAWA).

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