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Eco-Toxicity Dynamics in Compost Prepared From Organic Wastes.

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ABSTRACT

Waste accumulation is reported to be one of the serious environmental problems. Organic wastes such as organic fraction of municipal solid waste (OFMSW) or sewage sludge (SS) can be treated using aerobic microbial decomposition called composting. It is important to know when composts obtained in co-treatment processes turns to be safe but not toxic for the environment. In this study, we estimated eco-toxicity in the process of composting of mixture consisting of SS, OFMSW and sawdust polluted by oil (OS). Water flea *Daphnia magna,* infusorium *Paramecium caudatum* and higher plant *Avena sativa* were used in bioassays. The maximal toxicity of the compost mixture for the aquatic test-objects was observed on the 60th day of the treatment – it was calculated to be 71% for *P. caudatum* and 80% for *D. magna*. The minimal toxicity (10% and less) was observed on the 270th day of the treatment for both test-organisms. The lowest germination indexes of *A. sativa* were observed on the 30th and 60th days of the treatment – 45% and 54%, respectively, and the highest one - at the end of the treatment – 98% (day 270). In overall, co-treatment of the municipal wastes permitted to obtain a final product with no toxic but also no fertilizing properties.
Key words: municipal organic wastes, eco-toxicity, composting, bioassay

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INTRODUCTION

The process of composting has been defined as the aerobic thermophilic decomposition of organic wastes by microorganisms under controlled conditions which yield a partially stabilized residual organic material that will then be decomposed further when re-colonized by microorganisms [1]. The raw materials for the production of composts are commonly referred to as feedstock and these may be yard trimmings, woods chips, vegetable scraps, paper products, sorted municipal waste, carcasses of animals and bio solids [2,3] .

Composting of municipal wastes contributes to at least two environmental solutions – organic wastes treatment and fertilizers production, while co-composting of different waste types may improve efficiency of the treatment and quality of the final product [4]. However, in the process of co-composting toxic substances may be produced. For characterization of products of waste treatment, chemical analysis of their characteristics and estimation of their physical properties is usually employed. This analysis may be time consuming and not efficient in terms of minor pollutants causing serious environmental hazard. Therefore recently toxicity-based approach is used for assessing potential toxicity of the initial and treated wastes. The main advantage of performing bioassays is their integrative character [5]. Usually a battery of bioassays are used to estimate eco-toxicity, which include elutriate as well as direct tests based on organisms of different taxonomic and trophic levels [6,7].

The aim of this study was to estimate the eco-toxicity of compost in the process of co-treatment of three municipal organic wastes typical for Russia – OFMSW, SS and sawdust polluted by oil.

MATERIALS AND METHODS

Samples OFMSW and SS were selected on the enterprises of Kazan engaged in wastewater treatment and collection of solid waste. SS were collected from the wastewater treatment plant of Kazan city (Tatarstan Republic, Russia), OFMSW were collected from waste sorting station of Kazan city (Tatarstan Republic, Russia).

SS was mixed with OFMSW in ratio 2:1, then OS was added to the mixture to adjust the ratio C:N equal to 7-8. Three independent replicates of the compost mixtures were prepared. Samples of the compost mixtures were taken after 0, 30, 60, 90, 150 and 270 days of the process and analyzed separately. Each analysis was conducted in three replicates. Further, average values were calculated.

The toxicity was determined using the protozoan *Paramecium caudatum* [8], the water flea *Daphnia magna* [9] (ISO 6341) and the higher plant *Avena sativa* [10] (ISO 22030). The test procedures were performed according to the following guidelines.

The toxicity tests with *Paramecium caudatum* were carried out in a microplate with holes containing 0.3 ml of the test solution and examined under a Laboval microscope (Carl Zeiss, Jena). 10 individuals were exposed per hole for 1 h. After 1 h, mortality was determined.

The tests with *Daphnia magna* were performed in 50 ml beakers, filled with 20 ml of the test solution where five test organisms (aged 6-24 h) were subsequently added to each solution. They were not fed during the experiment. After 96 h, the number of immobilized specimens (mortality) was determined visually.

For the tests with *P. caudatum* and *D. magna* the percent of inhibition (I,%) for each of the dilutions was determined by comparing the number of immobilized or died test organisms to the starting number for the organisms.

In test with oats (*Avena sativa*) compost at 10% were added in soil. Investigations with germination test were carried out on grey forest soil (Haplic Greyzem). Pots were sowed with 10 oat seeds and after 10 days germination and root length were determined. The soil without added compost was served as control. Then germination index was calculated according to Zucconi et al. (1981) [11].

Statistical analyses were performed using an analysis of variance (ANOVA) for a randomized complete block design with α = 0.05. The means were compared using Fisher's Protected Least Significant Difference at α = 0.05. All graphs presented include means and standard deviation of the data.

RESULTS AND DISCUSSION

Many authors suppose that for eco-toxicity estimation of the wastes a battery of bioassays, both elutriate and contact ones, should be used. Comparison of results obtained by means of different bioassays helps to get more relevant results, e.g. to estimate influence of compounds which are non-water soluble or have a complex structure. [5,8,12,13]. On the Fig. 1, results of toxicity estimation of the compost for aquatic organisms are presented. Initial compost was toxic for both test-object, and toxicity raised in the first months of composting. The maximal toxicity was observed on the day 60, it was estimated to be 71% for *P. caudatum* and 80% for *D. magna.* Further, toxicity fell till 22% and 31%, respectively, on the day 90 and reached 10% and less on the day 270. It can be concluded that in the process of co-composting of municipal wastes toxic metabolites are produced. It suggests that this co-treatment process should be controlled using bioassay. After 270 days the final product turns to be not toxic for the environment.

In overall, *D. magna* was observed to be more sensitive compared to *P. caudatum*. This supports data published previously [8,14–16].

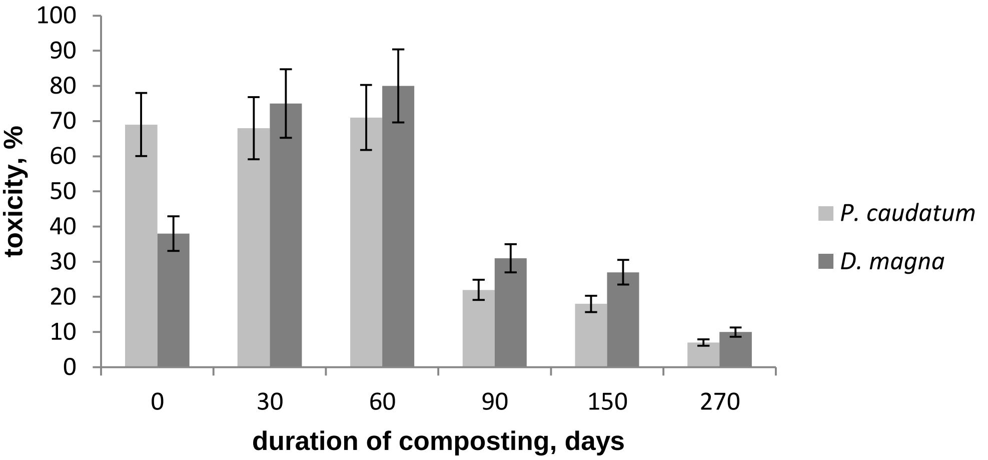

Figure 1: Toxicity estimated with *D. magna* and *P. caudatum* of the waste extracts from the compost taken at different composting times (1, 30, 60, 90, 150 and 270 days).

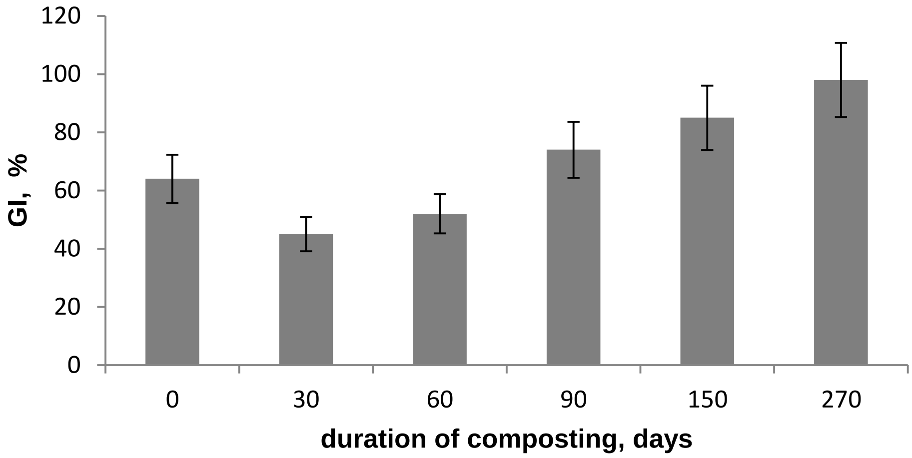

Figure 2: Changes in GI in contact test with *A. sativa* of soil amended with the compost taken at different composting times (1, 30, 60, 90, 150 and 270 days).

GI is a traditional index for phytotoxic assessment of composts [3,17]. In this study, phytotoxicity was estimated using contact bioassay with *A. sativa*. Long term contact bioassay in vegetation vessels produced information about agronomic value of the compost obtained [2,18]. Fig. 2 shows dynamics of GI calculated. GI of the initial compost mixture was equal to 64%.

During the first months of composting, significant decrease of GI was observed. Many compounds produced in the process of organic matter decomposition are described to be potentially toxic for plans: ammonium ions, low molecular fatty acids (such butyric, acetic, stearin and oleic), phenolic compounds (pyrocatechol, hydrocatechol, hydroxylthyrosol, thyrosol, oleuropein) and especially of tannin, которые по данным исследований могут присутствовать в компосте. [19–24].

In the process of composting, organic phytotoxic compounds could be decomposed to non-toxic, which could lead to GI increase [25]. After 270 days of composting GI reached 98%. That suggests that compost turned to be not toxic for the environment. However GI did not exceed 100% which means that the final product can not be used as a fertilizer.

CONCLUSIONS

Complex analysis of the results suggests that organic municipal solid wastes used in this study can be co-treated. This co-treatment leads to decrease of eco-toxicity of water extracts as well as of solid matrix of the wastes mixture after 270 days of composting. However, this co-treatment does not enable to obtain a final product with fertilizing properties.

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