

Toxic effects of tobacco on soil worms in densely populated cities

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Abstract. Soil contamination by cigarette butts has become a serious problem in recent years. The culture of earthworms *Eisenia foetida* (Sav, 1826) has been used in this scientific work as an object for research. The toxic effects of tobacco were investigated during vermicomposting of cigarette butts. Analysis of changes in the age structure of the population showed that the most resistant to the action of toxic units are sexually mature individuals and juveniles. Larvae and juveniles are most sensitive to soil contamination by cigarette butts. The tested earthworm populations under the influence of experimental drawings lost the productivity of their cocoons. Thus, regular dropping of cigarette butts on the soil surface leads to gradual destruction of earthworms in urban soil.

1 Introduction

The Russian Federation is one of the most smoking countries in the world. A lot of smokers throw their cigarette butts just under their feet, on lawns or simply leave them on the ground. There may be over one thousand of tobacco butts per square meter in cities [1-5]. The fauna of the soil is a sensitive component of the eco system, saprophytes are the most vulnerable part of it [6, 7]. Earthworms having devoured the substrate, pass all the pollutants which get into the soil through their organism. Regular consumption of the contaminated fragments of soil leads to full or partial elimination of the earthworm's population as a result [8].

The interdependence between the pollutants in the soil and its suitability for habitation of live organisms may not always be direct [9]. Toxic effect of certain pollutants can be neutralized, weakened or reinforced by presence of some other pollutants.

The integral toxic ability of the soil is not dependent on the toxic ability of some separate units which the soil contains. Bio testing is the most reasonable method for defining the integral toxic ability of the soil [10].

Live organisms which possess soft covers are the most likely to be negatively influenced by pollutants.

ZhaoTong and his colleagues from The University of Xi'an have counted 4500 trillions of cigarette butts which get into the environment yearly [11].

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2 Materials and Methods

While vermicomposting, *Eisenia foetida*, *Aporrectodea caliginosa*, *A. rosea*, *Lumbricus rubellus*, *L. terrestris* can be used as objects for laboratory tests.

The culture of earthworms *Eisenia foetida* (Sav, 1826) has been used in this scientific work as an object for research.

The choice of *Eisenia foetida* was made due to its wide range of tolerance to many environmental factors and its ability to regain the number of population rather quickly as soon as all the stressful effects have been removed from it.

Eisenia foetida is a hermaphrodite with cross fertilization. After copulation a cocoon in shape of a lemon appears which produces some tiny, almost transparent worms with 7 to 20 mm in size.

Worms become mature in about 3 to 6 weeks after their birth. The columellate weight of a worm varies from 0.53 up to 0.96 gm. *Eisenia foetida* reaches its age of puberty in 12 weeks.

The worms lay 1 to 2 cocoons weekly. The duration of *Eisenia foetida*'s life may be more than 5 years, 7 years in comfortable conditions. The worms keep their reproductive activity during all their life. Their breeding usually takes place in warm season.

According to the literary data, the worms enlarge their population twice as much every 60 days. The experimental data were received while conducting a model test in laboratory conditions. The analysis of the index of the chemical essences in the solution of cigarettes were held using the widespread methods by means of spectrophotometry.

Tobacco was extracted from a cigarette and put into a chemical glass containing some Nitric Acid solution (50 ml). It was infused and filtered through a paper filter during 24 hours. Just before the experiment, the extraction was dissolved (10 times less), then it was filtered again. pH of the substrate and the suspension was defined by pH meter FieldScout SoilStik.

In order to get agro ecological characteristics off the examined population of the compost earthworms, 10 species from every population were selected with 3 x multiple repetition, then they were placed in some plastic containers of the same size (10x15 cm).

The containers with the examined culture were situated in a dark, well heated room where the permanent temperature ranged 20-25 °C. The general duration of the test made 22 weeks.

A new layer of the substrate 2 cm thick was added to the containers as the means of extra nutrition weekly. The ingredients of the substrate were peat, humus and saw dust of larch trees in equal proportions. The effectiveness of the substrate was proved by the control group.

In order to get a watery drawing, 5 cigarette butts were infused in 100 milliliters of distilled water during 24 hours. The infused solution was then used as the means of impact on the earthworms' culture. The volume of irrigation was defined by the degree of the moistening of the upper centimeter of the soil with the help of the moisture meter TDR-100.

The irrigation by the water drawing from cigarette butts was fulfilled according to the following scheme:

- Line number 1 (control). Water irrigation every 72 hours.
- Line number 2. Water irrigation Winston Xstyle every 72 hours.
- Line number 3. Water irrigation Kent every 72 hours.

3 Results

The main results based upon the chemical substance of the water drawings from the tested cigarettes are displayed in the table number 1.

Table 1. The chemical ingredients of the examined water drawings.

Parameters of the water drawing	The brand of cigarettes	
	Kent	Winston
pH of solution	6.1	6.4
The contents of pitchy substances, mg	6.0±1.68	8.0±2.34
The contents of nicotine, mg	0.3±0.05	0.7±0.03
The concentration of furfural, mg/ml	2.045±0.40	1.891±0.37
The concentration of phenol mg/ml	0.265±0.03	0.680±0.04
The concentration of formaldehyde, mg/ml	0.055±0.01	0.012±0.001
The concentration of methanol, mg/ml	6.57±2.05	45.77±6.81

The main results based upon the chemical substance of the water drawings from the tested cigarettes are displayed in the table number 1.

According to the majority of the parameters (the presence of tar, nicotine, phenol, methanol) in Winston Xstyle exceeds all the markers of Kent brand.

The dynamics of the populational development was defined weekly during 22 weeks, taking into consideration the number of grown up species, young worms and cocoons. The productivity of the population was estimated according to the following markers: the number of cocoons per week; the number of larvas hatched from one cocoon; the time of cocoon's incubation; the number of grow up worms per month.

One of the main integral markers of the productive properties of the population is the number of the grown up species. They were calculated weekly during all the period of their cultivation. Afterwards they were all summed up.

The age structure of the population is its most important characteristics which shows its different groups of species correlated with each other. The age structure influences the birth rate, mortality, defines its ability for breeding at the present moment. The correlation of the markers of birth rate and mortality gives us a good chance to predict all the possible perspectives.

The dynamics of the age structure of worms in each population was defined by the percentage of the general number of all the worms when 7, 12, 17, 22 weeks of the tests had passed. During all the period of the experiment the population of the line number 1 (control) was represented by all the age categories. In the line number 2, being irrigated by the drawing of Winston Xstyle cigarettes, the group of mature species constantly dominated over the rest of the groups except for the seventeenth week, when it had been outnumbered by a teenage group.

The population of the line number 3, irrigated by the drawing of Kent cigarettes, at the beginning of the test didn't have all the members. Teenagers were absent the seventh week of the recording. Not a single young worm was registered the 12 th week. But all the age groups were present in the line number 3 the 17th and 22 nd week.

The mature species had dominated during all the period of Vermi cultivation. The number of the larvas had radically decreased by the end of the experiment (Picture 1).

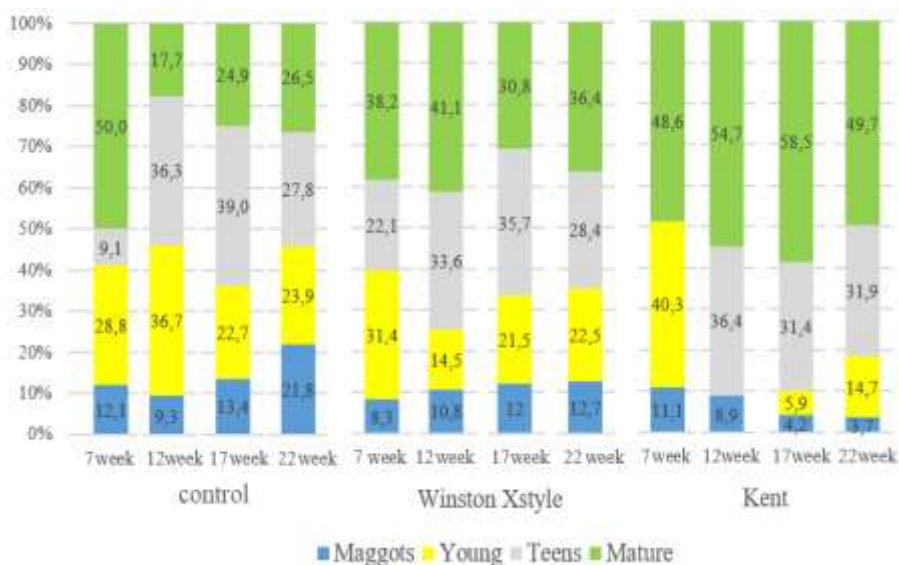
The earthworms get into their age of puberty by roughly 12 th week of their lifetime. From this moment on, they are able to copulate on regular basis and lay their egg cocoons. While studying the populations of the compost earthworms-the number of the cocoons produced by every worm per week, the number of larvas hatched out of one cocoon and the time of cocoons' incubation were taken into account.

The number of cocoons laid by one worm per week is a very important criteria for the whole population in general.

The examined populations were divided into two groups according to the number of the laid cocoons in each of them: the fertile one (Line number 1 and number 2) and a less fertile (Line number 3).

The incubation period of cocoons means all the time period since they lay eggs until the larvas appear. The incubation period of the cocoons is a very important marker of productivity of the population. The shorter it is, the more productive is the population.

In the 22 nd week of the experiment the largest number of the cocoons was laid by the worms from the control group (20.7 cocoons) whilst in the line number 2 there were only 8.3 cocoons and in the line number 3 just 2.4 cocoons.



Pic. 1. The age structures of the examined populations *Eisenia foetida*, %.

The control group was characterized by the shortest incubation period (19.3 ± 1.4 days), at the same time the lines which were under direct influence of the cigarette drawings had a much longer period of incubation (line number 2- 20.3 ± 1.8 days, line number 3- 21.7 ± 2.1 days).

The ability to hatch means the quantity of viable larvas which come from the same cocoon. This marker characterizes the population growth by certain conditions and depends a lot on the peculiarities of the present animal community.

The ability of the cocoons to hatch had a similar tendency: the cocoons of the control line number 1 produced 5.47 ± 0.8 larvas, line number 2- 2.87 ± 9.4 larvas, line number 3- 2.27 ± 0.5 larvas.

The experiment has shown that the amount of the cocoons laid by the 22 nd week is a subtle indicative marker of the influence of cigarette drawings on the earthworms' viability.

The authenticity of the difference ($p < 0,01$) is marked between the control group and the line 3.

4 Conclusion

The analysis of the changes taking place among the age structure of the population has shown that the most resistant to effect of the toxic units are mature species and teenagers. Larvas and youth are the most sensitive to pollution of the soil by cigarette butts. The substances included in the tobacco, harm not only the organisms themselves but their ability to breed. The tested populations of earthworms have lost productivity of their cocoons under the influence of the experimental drawings.

The longer terms of incubation periods and less capability of the larvas to survive are definitely some markers of population's depression.

Thus we've come to a conclusion that regular falling of cigarette butts down on the surface of the soil leads to gradual destruction of such an important saprophytes' group as earthworms in the soil of cities.

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