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ENVIRONMENTAL IMPACT OF EARTHWORM (*LUMBRICIDAE*) EXCRETORY ACTIVITY ON PH-BUFFERING CAPACITY OF REMEDIATED SOIL

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The environmental impact of metabolic activity of saprophages specimen on pH-buffering capacity of devastated lands was studied. Earthworms (*Lumbricidae*) for investigations were taken from artificial forest plantations grown on the lands reclaimed from the mining industry. It is shown their positive influence on acid-alkaline buffering capacity of devastated lands. The quantitative assessment of the earthworm impact on pH buffering value of remediated soil is represented. It is experimentally proved that earthworm cast does have higher acid-alkaline buffering capacity compare to buffering of loess loam. It was found that the acid-alkaline buffering capacity of artificial soil as a result of their excretory activity had increased on 17.7%. This is positive for its ecological properties and economic value.

Keywords: devastated lands, forest remediation, ecological properties of soil, earthworm excretory activity, soil pH-buffering.

In the South-eastern part of Ukraine degraded areas as a result of mining activities have formed. These lands are an integral part of modern powerful disruptive network in consequence of anthropogenic factor. Agricultural and forest remediation of damaged soil is used to eliminate the consequences of coal mining [13]. Thereby the chemical compounds of mining spoil, toxic for human health and soil biota get into the rehabilitated soil. One of the most important factors of soil remediation is considered to be the forming of special conditions for successful existence of soil biota. Representatives of ground animals are numerous in soil and facilitate improving native and artificial soil properties [14–16].

Ability of soil to keep natural or artificially formed potentials of fertility, and to inhibit (neutralize, counter) an external harmful influences and impacts is called buffering capacity. Buffering capacity of soil is often considered as resistance to changes of actual reaction under influence of different environmental impacts [10, 12]. It is called acid-alkaline buffering or pH-buffering, which neutralizes acidification or alkalizing. Acid or alkali which appears in the soil solution reacts with the soil-absorbing complex, and it reduces the change of pH-reaction.

Soil with high content of Ca^{2+} and other alkaline cations in the soil-absorbing complex demonstrates buffering against acidification. High H^{+}-content in the soil-absorbing complex determines buffering capacity against alkalizing. Besides acid-alkaline buffering of soil there exist the other types of one. Functioning of soil buffering systems ensures stability of soil fertility as main soil integral function.

It is known that “live” phase of soil can greatly effect not only its productive properties (fertility), but also participate in quantitative and qualitative changes of other ones [3, 4, 17]. Fossorial, trophical and excretory activities of invertebrates make a significant contribution to transformation of soil properties. It can influence on the mobilization (release) and immobilization (deposit) of fertility elements in the soil [17, 18].

The identification of soil biota involvement (especially earthworms) into the process of optimizing of ecological properties of damaged soil was studied particularly. Earthworms generally live in the upper soil layer. Their excretory activity has promoted to top layer formation from earthworms cast of ground or soil. An earthworm cast is represented with the soil biogenic element. Therefore evaluation of its impact on remediated soil buffering capacity has a scientific and practical value.

Materials and methods

Investigations were conducted in Steppe zone of Ukraine (Western Donbas, Dnipropetrovsk region) with continental type of climate. Moisture is the main limiting factor for existing of soil biota here. Products of the coal mining (toxic water-soluble salts, compounds of heavy metals) make the negative influence on the environment in the Western Donbas territory [1, 2].

The earthworm (*Lumbricidae*) cast was taken as this research subject. Researches were conducted in 2012. Soil samples and earthworm cast were sampled in the forest remediation area in maple planting on loess loam with porous structure (2nd variant of remediation). Soil samples were selected according to the Soil Science Manual [9] from depth of 0–10 cm. Upper layer of investigated variant was presented by pure loess loam. The representatives of *A. caliginosa* are of endogeic earthworms, saprophages, second-decomposers, nitro liberates and humificators. Fresh cast of *Aporrectodea caliginosa* (Savigny, 1826) are located onto soil cover [8, 11].

For calculation of buffering areas the numerical quadrature method was used. The goal was achieved with the use of Simpson formula [6, 7]. Measurement of actual acidity (pH) of control and experimental samples was conducted in three replications. Were estimated arithmetic average, its standard error and significant difference of values averages [5].

For determination of acid-alkaline buffering capacity of earthworm cast and loess loam the techniques of Arrhenius and methods of potentiometry were used [10, 12]. Soil buffering capacity determination is based on identifying of pH-value changes after adding acid or alkali. The result is shown in the buffering curves.

Results and discussion

The obtained results of pH determination of soil samples in the acidic range approved the loess loam has a native conditionally neutral reaction (6.60), and the earthworm cast did it close to neutral (7.16). When even a small amount of acid (3 ml) was added, the loess loam reaction was changed from 6.60 to 5.07 (acidic), while the earthworm cast with initial pH 7.16 had acquired conditionally neutral reaction (6.55), keeping almost on the same neutral level the addition of more volume of acid (Table 1).

Table 1

Results of measurement of buffering in loess loam, earthworm cast and sand (acid range)

№ of sample	Volume of adding reagent, ml		Acidity (pH_{H_2O})		
	0,1 M HCl	H_2O dist.	Sand	Loess loam	Earthworm cast
1	0	25.0	6.95±0.05	6.60±0.05	7.16±0.06
2	1.5	23.5	3.25±0.10	6.09±0.07	6.78±0.08
3	3.0	22.0	2.80±0.05	5.07±0.09	6.55±0.05
4	4.5	20.5	2.52±0.04	4.64±0.07	6.42±0.07
5	6.0	19.0	2.45±0.05	4.43±0.08	6.33±0.11
6	7.5	17.5	2.36±0.06	3.93±0.11	6.24±0.09
7	9.0	16.0	2.29±0.04	3.73±0.08	6.10±0.08

Note: in what follows average and standard error are given.

When a small amount of alkali solution (1.5 ml) was added, the loess loam reaction remained conditionally neutral (6.70). In the case of earthworm cast it became slightly alkaline

(7.43) from the initial reaction close to neutral (7.16). If more volume of alkali (6 ml) was added, both loess loam and earthworm cast reactions became alkaline (8.25 and 8.87, accordingly). Adding the maximum volume of alkaline (9 ml) made the alkaline reaction in both samples more developed (Table 2).

Table 2

Results of measurement of buffering in loess loam, earthworm cast and sand (alkaline range)

№ of sample	Volume of adding reagent, ml		Acidity (pH_{H_2O})		
	0,1 M NaOH	H_2O dist.	Sand	Loess loam	Earthworm cast
1	0	25.0	6.95±0.05	6.60±0.05	7.16±0.06
2	1.5	23.5	11.45±0.05	6.78±0.08	7.43±0.07
3	3.0	22.0	11.65±0.10	7.20±0.10	8.01±0.06
4	4.5	20.5	11.72±0.07	7.72±0.07	8.55±0.05
5	6.0	19.0	11.87±0.06	8.25±0.10	8.87±0.07
6	7.5	17.5	12.05±0.05	8.75±0.08	9.01±0.10
7	9.0	16.0	12.05±0.10	9.35±0.07	9.20±0.07

The cast buffering area is located between the sand titration curve and the cast titration curve. The loess loam buffering area is located between the sand and loess loam titration curves. The titration curves arrangement indicates that the buffering area size for cast (32.5±0.52 cm^2) is more than buffering loess loam one (18.1±0.51 cm^2) on 79.6% in the acidic range (Fig. 1). The statistical differences between the areas of loess loams and cast buffer capacity with a significance level less than 0.01 (in the acid range) were established after a statistical estimate of a distinction between mean values.

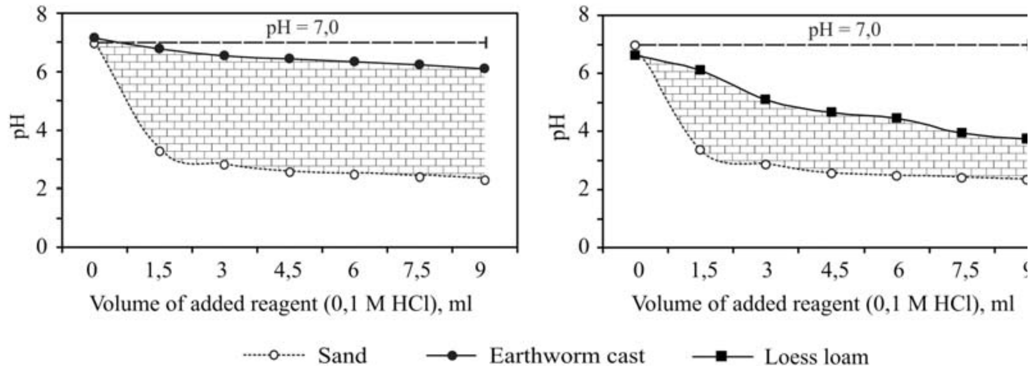

Fig. 1. The buffering curves for earthworm cast and loess loam in the maple planting and sand (unbuffered system) in acidic range.

The arrangement of titration curves in alkaline range indicates that the average cast buffering area size (28.7±0.06* cm^2) is less than the loess loam one (33.8±0.43 cm^2) on 17.8% (Fig. 2). The significant differences between the areas of loess loams and cast buffer capacity with a significance level less than 0.05 (in the alkaline range) were established after a statistical estimate of a distinction between mean values. The total (acid-alkaline) buffering area size of earthworm cast (61.1±0.53*** cm^2) was more than the loess loam one (51.9±0.60 cm^2) on 17.7%. The significant differences between the areas of loess loams and cast buffer capacity with a significance level less than 0.001 were established after a statistical estimate of a distinction between mean values.

Conclusion

The total buffering area size of earthworm cast was more than loess loam one. The acid-alkaline buffering capacity of native cast was estimated as very high in the acid range and as low

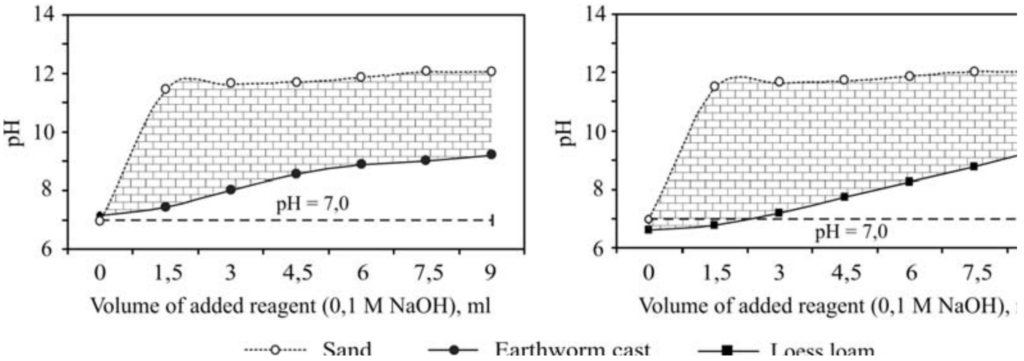

Fig. 2. The buffering curves for earthworm cast and loess loam in the maple planting and sand (unbuffered system) in alkaline range.

in alkaline one. The difference might be explained by the cast chemical composition.

The soil acid-alkaline (total) buffering capacity is raised a bit due to enriching it with the earthworm cast as a result of the excretory activity. As a result the soil became more resistant to the harmful effects of mine spoil acidic solutions. Thus the activity of soil invertebrate saprophages influences positively on the ecological properties of soil during remediation activities.

Results of our experiment suggest that the acid and alkaline earthworm cast buffering capacity is significant more on 17.7% than initial soil. It can promote positive changes of ecological condition of remediated soils.

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СЕРЕДОВИЩЕПЕРЕТВОРЮВАЛЬНИЙ ВПЛИВ ЕКСКРЕТОРНОЇ ДІЯЛЬНОСТІ ДОЩОВИХ ЧЕРВ'ЯКІВ (*LUMBRICIDAE*) НА PH-БУФЕРНІ ВЛАСТИВОСТІ ВІДНОВЛЕНИХ ҐРУНТІВ

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Вивчався екологічний вплив метаболічної активності окремих представників сапрофагів на pH-буферну здатність насипних ґрунтів рекультивованих територій. Як об'єкт досліджень було обрано представників дощових черв'яків (*Lumbricidae*), що населяють штучні лісові насадження рекультивованих ділянок на землях, порушених відходами гірничо-видобувної промисловості. Показано їх позитивну роль у формуванні кислотно-лужної властивості насипних ґрунтів. Наведено кількісну оцінку впливу дощових черв'яків на pH-буферність рекультивованих ґрунтів. Експериментально доведено, що копроліти дощових черв'яків мають вищу кислотноосновну буферну ємність порівняно з буферністю лесоподібного суглинку. З'ясовано, що в результаті їх екскреторної діяльності підвищувалася кислотно-лужна буферна здатність штучного ґрунту на 17,7%, що позитивно позначалося на його екологічних властивостях і економічній цінності.

Ключові слова: штучний ґрунт, лісова рекультивація, екологічні властивості ґрунту, екскреторна діяльність дощових черв'яків, рН-буферність ґрунту.

СРЕДОПРЕОБРАЗУЮЩЕЕ ВОЗДЕЙСТВИЕ ЭКСКРЕТОРНОЙ ДЕЯТЕЛЬНОСТИ ДОЖДЕВЫХ ЧЕРВЕЙ (*LUMBRICIDAE*) НА РН-БУФЕРНЫЕ СВОЙСТВА ВОССТАНОВЛЕННЫХ ПОЧВ

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Изучалось экологическое влияние метаболической активности отдельных представителей сапрофагов на рН-буферную способность насыпных почво-грунтов рекультивированных территорий. Объектом исследований являлись представители дождевых червей (*Lumbricidae*), обитающие в искусственных лесных насаждениях рекультивированных участков на землях, нарушенных отходами горнодобывающей промышленности. Показана их позитивная роль в формировании кислотно-основных буферных свойств насыпных почво-грунтов. Приведена количественная оценка влияния дождевых червей на рН-буферность рекультивированных земель. Экспериментально доказано, что копролиты дождевых червей имеют более высокую кислотно-основную буферную емкость по сравнению с буферностью лессовидного суглинка. Установлено, что в результате их экскреторной деятельности кислотно-щелочная буферная способность искусственной почвы возрастала на 17,7%, что положительно сказывалось на ее экологических свойствах и экономической ценности.

Ключевые слова: искусственная почва, лесная рекультивация, экологические свойства почвы, экскреторная деятельность дождевых червей, рН-буферность почвы.