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THE INFLUENCE OF COCONUT FIBRE AND SALTS COMPOSITE USED FOR ELIMINATING SLIPPERINESS AND ON ROADS ON SOILS

WPŁYW KOMPOZYTU MIESZANKI WŁÓKIEN KOKOSOWYCH I SOLI STOSOWANYCH DO USUWANIA ŚLISKOŚCI JEZDNI NA GLEBY

Abstract: The subject of the study is analyzing the impact of coconut fibre and salt mixture used for eliminating slipperiness on roads on roadside soil. The tests were done on the soil samples taken from the fixed areas twice: in the autumn before applying the composite and in the following spring. Laboratory tests indicated decrease of conduciveness in soil after using the composite in wintertime. This can cause decreasing saltiness of roadside soil. In contrast to commonly used methods of eliminating slipperiness on roads with salts only applying the composite could diminish the negative effects of roadside soil saltiness.

Keywords: saltiness, eliminating slipperiness on roads, roadside soil, coconut fibre, easily soluble salts

Introduction

Saltiness is one of chemical soil pollution which has many reasons: from natural processes, the dispersion of fungicides or insecticides or fertilizer on growing crops to changes caused by substances directly introduced to environment by people.

The destructive force of soil saltiness is caused mainly by concentrating the soil which makes it hard for plants to absorb water and nutrient substances. Soil saltiness also changes the ionic balance of environment, soil characteristics and presence of toxic elements. The process can be noticed mainly in alkalization of soil environment [1].

One of the reasons of soil saltiness caused by people is using chemical substances for maintaining roads in wintertime. Salts like NaCl and $CaCl_2$ are commonly used for eliminating road slipperiness. The substances can spread on roadside soil increasing the

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area of soil saltiness [2]. This explains why using salts on the roads in wintertime has serious impact on the local areas.

Negative effects of using salts on roads were noticed in the 50s when the damage of "green areas" in urban locations was observed. It was the time when the studies and analysis of effects of using salts on roads were carried out. The analysis conducted in Warszawa by Dobrzanski et al indicated the negative effect of salt on the urban plants [3]. The authors of the study have shown almost complete saltiness of the soil caused by salt used on roads. During the following years similar studies were carried out in many Polish cities [4–7].

A lot of attention in the environmental studies was devoted on the impact of chemical substances on roadside plants. Czerniawska-Kusza et al (2004) conducted detailed observations: they indicated significant impact of NaCl on roadside trees in Opole [8]. The study was based on observing damages on the tree leaves and branches. It was concluded that the most damaged leaves accumulate sodium and chlorine the most.

Bach et al carried out a similar observation but in a different city – Krakow [4]. Tests made on roadside soil revealed soil saltiness and more specific changes in its composition that impacts the accessibility of microelements and quality and quantity of microorganisms.

The environmental effects of using salt on roads on the roadside soil are: relocating nutritious cations, decreasing soil penetrability and scattering soil colloids what is more, the ions of salt can draw heavy metal ions causing soil damage [9]. Both sodium and chlorine have considerable effect on nitrogen changes and decrease soils structure through reduction organic substances [10].

The awareness of negative impact of using salts for eliminating slipperiness on roads on the roadside soil shows the need of searching alternative methods of maintaining roads in wintertime. Nowadays, the most effective substances for eliminating slipperiness on roads used in big quantities can cause dramatic changes in roadside environment. Hence, an effective way of protecting roads from slipperiness which is also safer for environment is needed.

The aim of the studies in the this thesis was defining the physical and chemical changes of roadside soils after using the composite of coconut fibre and salt in wintertime and assessing the usefulness the composite.

Materials and methods

Coconut fibre (coconut chips) are fraction of crumbled coconut fruit. The main aim of coconut fibre is to maintain the surface of easily soluble salt (NaCl), which will react with frozen road surface. Lengthening the time of using the composite would help in dissolving the ice and snow on the road quickly and effectively. This technology would reduce the amount of used salt and would stop the salt on the road during the next applying process. What is more, coconut chips re close to neutral pH and it can help to save balance of roadside soil. The composite used for the tests was created from coconut fibre and salt mixed in weight proportion 1:10.

The tests of the impact of coconut chips and salt mixture were carried out on the roads among the fields. The exact location of the roads are: Obrowiec – Gogolin, Zakrzow – Zakrzow Osada, Kamien Slaski – Gogolin and Kosorowice – Kamien Slaski. On each of four test areas two zones were created: A and C – zones directly next to the road on the left and right and zones B and D adjacent to zones A and C. the zones were rectangular, sized 10 meters long and 1 meter wide (Fig. 1). Soil samples were taken on

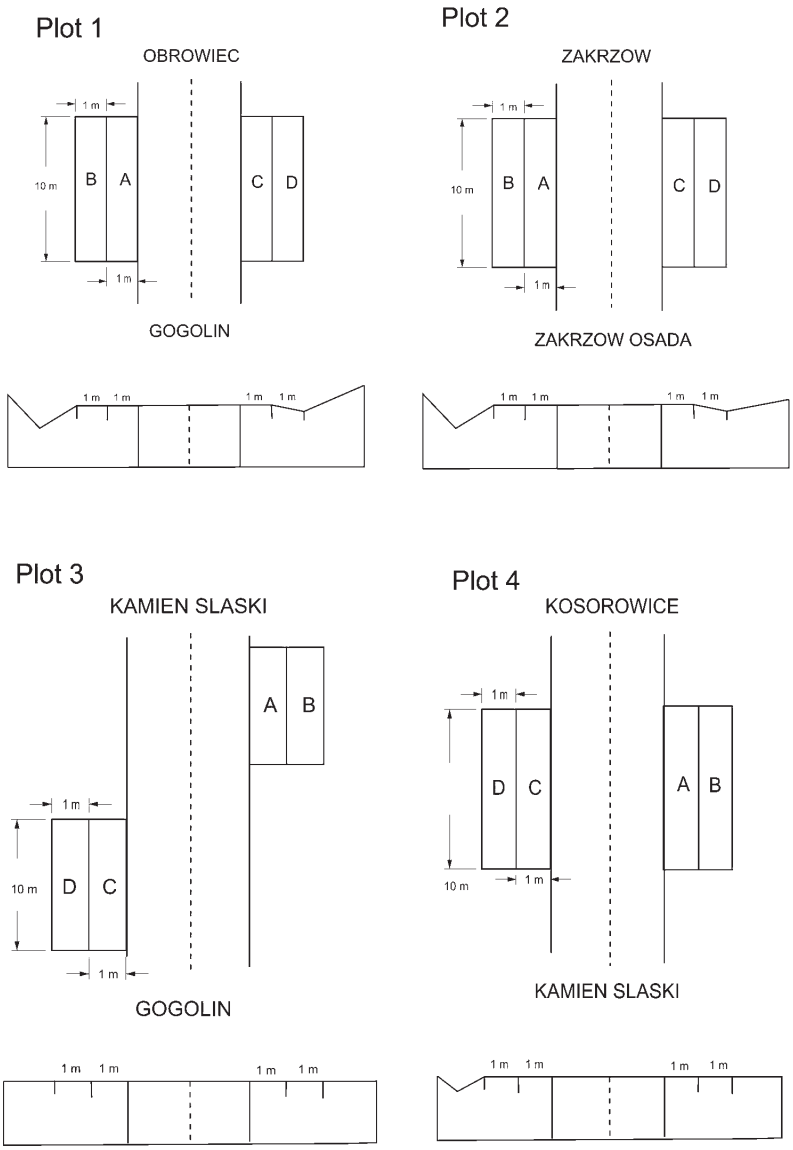

Fig. 1. Experimental plots located along roads

Table 1

The mechanical composition of roadside grounds

Zone of roadside	Percentage content of fractions with diameter [mm]												
	>2	<2	2–1	1–0.5	0.5–0.25	0.25–0.1	0.1–0.05	Σ **>0.05**	0.05–0.02	0.02–0.005	0.005–0.002	Σ **>0.002**	<0.002
1A	10	90	4	37	34	17	6	**98**	2	0	0	**2**	0
1B	12	88	5	19	34	23	5	**86**	4	0	8	**12**	2
1C	14	86	10	34	27	18	8	**97**	2	1	0	**3**	0
1D	18	82	3	25	32	19	14	**93**	6	0	0	**6**	1
2A	18	82	4	23	33	18	10	**88**	7	3	0	**10**	2
2B	9	91	5	16	24	15	16	**76**	14	6	0	**20**	4
2C	9	91	2	10	40	18	10	**80**	8	4	1	**13**	7
2D	9	91	5	17	30	18	0	**70**	18	5	0	**23**	7
3A	6	94	7	18	31	18	11	**85**	10	4	0	**14**	1
3B	7	93	6	19	30	22	9	**86**	8	4	0	**12**	2
3C	16	84	6	26	33	20	7	**92**	8	0	0	**8**	0
3D	10	90	2	21	27	20	14	**82**	7	6	0	**13**	3
4A	18	82	5	21	31	21	6	**79**	8	6	0	**14**	2
4B	18	82	8	24	29	19	7	**87**	9	2	0	**11**	2
4C	9	91	4	25	38	18	8	**93**	4	2	0	**6**	1
4D	6	94	3	25	38	19	5	**90**	7	1	0	**8**	2

the deep of 0–30 cm twice: in the autumn (November 2014) and spring (April 2015). Also control samples were taken in the distance of 4 meters from the road for every zone. The samples consist of 8 individual samples taken from each zone.

The samples were dried and then homogenized and then sieved. The samples were also divided into a few sections: elements bigger than 2 mm, elements sized 1.0–2.0 mm. In the section where elements were smaller than 1.0 mm aerometric Casagrand's method with Proszynski's modification was used to determine granulometric composition of the sample. The fractions bigger than 0.1 mm were determined granulometirically by using sieve and water method. The following chemical characteristics were also determined: saltiness by conductometric method based on electrolytic conductivity of water-soil mixture in weight proportion soil/water 1:5 and pH in H_2O and KCl by potentiometer (weight proportion soil/water 1 : 2,5).

Results and discussion

Granulometric composition. According to PTG criteria (2008) the analysis of the samples from test areas indicated that the soil is mainly built of sand (semiloam and loam) (Table 1). Only section 2D is an exeption – its soil has been classified as sandy loam. The presence of loose soil causes better water penetrability. That is why salt solution goes through the gaps in the soil quickly and causes smaller saltiness.

The pH values. Using the composition of coconut fibre and salt for eliminating slipperiness of the road did not change pH parameters negatively. The pH indicator of the samples showed neutral and minimal alkaline pH of soil. Before using the composite pH was about 6.36–7.03 and after applying the mixture it was about 6.60–7.23 (Fig. 2, 3). Many sources indicate that alkaline pH of soil can be caused by many factors both natural and anthropogenic. It is suggested that the pH increase after wintertime was caused by the features of the source rock. The samples were taken from the limestone background and it could cause higher pH in the spring. Findlay and Kelly states that increasing pH is caused by the change of ionic composition caused mainly by carbonate salts [11].

Analysis of the tests shows a specific link: the further the sample was from the road, the smaller the pH indicator. It can also be confirmed by other studies Chudecka et al [12].

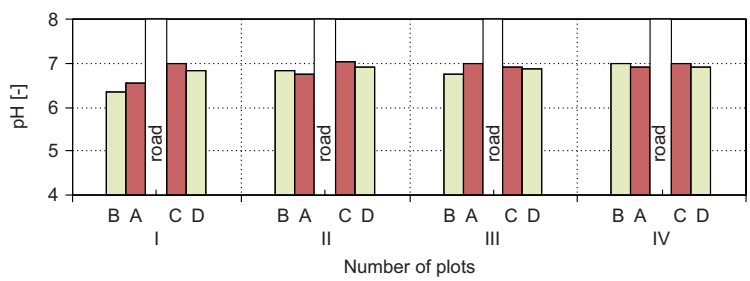

Fig. 2. The pH (1nKCl) values of roadside soil before applying the mixture of NaCl and coconut fibre (10:1) – autumn 2014

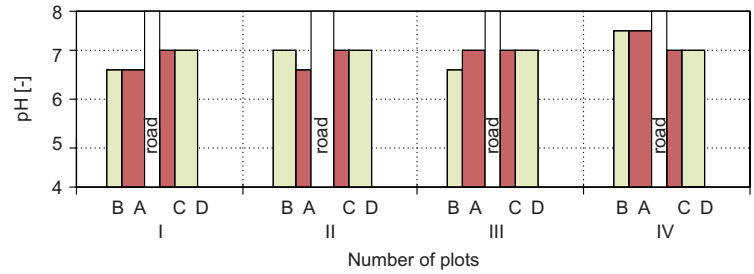

Fig. 3. The pH (1nKCl) values of roadside soil after applying the mixture of NaCl and coconut fibre (10:1) – spring 2015

Soil salinity. To determine the level of saltiness the key parameter is electrical conductivity. In the autumn the conductivity was about 190 μS · cm^{-1} and 50–160 μS · cm^{-1} in the spring. The smallest values were noticed in area number 1 and the biggest in area number 3 (Fig. 4, 5).

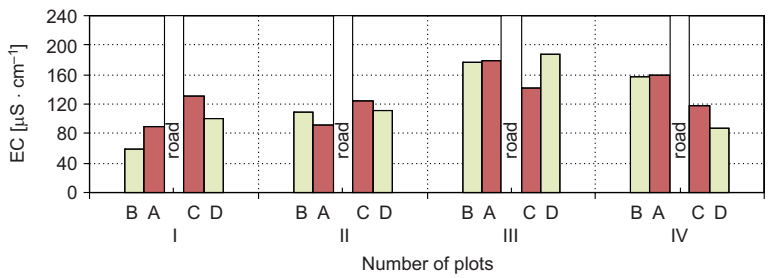

Fig. 4. Mean electrical conductivity (EC) of roadside soil before applying the mixture of NaCl and coconut fibre (10:1) – autumn 2014

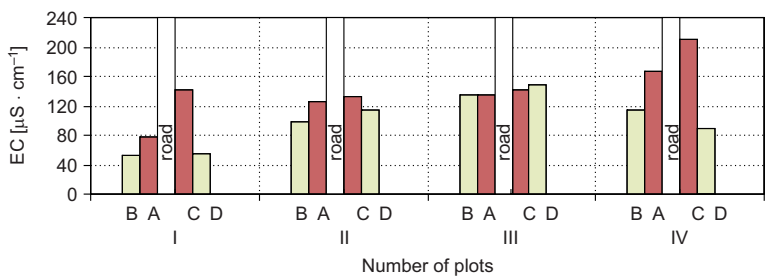

Fig. 5. Mean electrical conductivity (EC) of roadside soil after applying the mixture of NaCl and coconut fibre (10:1) – spring 2015

The results obtained during spring-autumn period indicated a decreasing tendency in electrical conductivity of soils collected from a ridge adjoining the roadway, from 140 to 125 μS · cm^{-1}. Whereas no difference was revealed in EC values in soils located in the distance of 1–2 m from the ridge road (Fig. 6) – mean EC value was 115 μS · cm^{-1}.

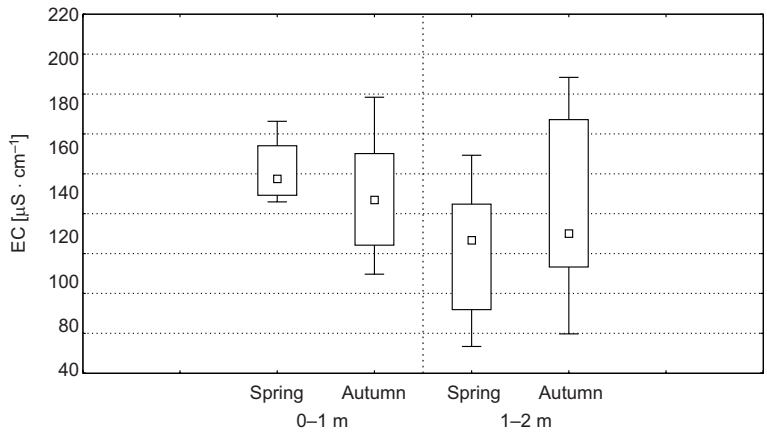

Fig. 6. Electrical conductivity values (EC) of roadside soil samples collected from experimental plots in autumn and spring

Significant deviation was observed in area I and III in the zones located the furthest from the road. The board value that indicates significant negative changes in soil is 2000 $\mu S \cdot cm^{-1}$. The results do not exceed this value hence the soil is not heavily salted. After the study, the significant decrease of soil salinity was observed and the following dependence: the further the soil from the road, the smaller the conductivity. This relation is easily noticed for soil samples from area number 1, where the electrical conductivity indicator decreased by 15 % after applying the composite. Similar relations were confirmed by Brogowski's studies [13]. Small conductivity can be caused by the fact that easily dissolving salt from the mixture could sink into deep horizons of the ground [8, 14]. It can also be caused by using smaller amount of salt for eliminating the slipperiness on the road in this study than it is generally done. It can be stated that applying the mixture of salt and coconut fibre did not cause conductivity increase and it does not cause growth of soil salinity.

Conclusions

1. Using chemical substances in winter road maintaining causes deteriorating of roadside soil conditions. This is why there is a need for alternative ways of eliminating slipperiness which would affect natural environment less.

2. The test results based on soil samples from the chosen areas located next to roads indicated reduction of soil saltiness after applying the salt-coconut fibre composite. The results of the study are based on two conduciveness tests carried out in autumn and spring.

3. Using the salt-coconut fibre composite seems to be an alternative cheap way of eliminating slipperiness on roads. Quite long deposition of the mixture on the road caused gradual release of salt and by this, reduced the amount of used salt.

References

[1] Nelson SS, Yonge DR, Barber ME. J Environ Eng. 2009;135(7):505-510. DOI: 10.1061/(ASCE)0733-9372(2009)135:7(505).
[2] Banasowa V. Ecology (CSSR). 1985; 4:315-328.
[3] Dobrzański B, Czerwiński Z, Borek S, Kępka M, Majsterkiewicz T. Soil Sci Ann. 1971;22(1):59-74. http://ssa.ptg.sggw.pl/files/artykuly/1971_22/1971_tom_22_nr_1/tom_22_nr_1_59-74.pdf.
[4] Bach A, Pawłowska B. Ecol Chem Eng. 2006;13(6):455-461.
[5] Tołoczko W, Trawczyńska A, Niewiadomski A. Proc ECOpole '06, 2006;1:263-266.
[6] Lundmark, A., Olofsson, B. Water Air Soil Pollut. 2007;182 (1-4),173-185. DOI: 10.1007/s11270-006-9330-8.
[7] Kochanowska K, Kusza G. Ecol Eng. 2010;23:14-21. http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-article-BPW9-0010-0002.
[8] Czerniawska-Kusza I, Kusza G, Dużyński M. Environ Toxicol. 2004;19:296-301. DOI: 10.1002/tox.20037.
[9] Goodrich BA, Koski RD, Jacobi WR. Water Air Soil Pollut. 2009;198(1-4):165-188. DOI: 10.1007/s11270-008-9835-4
[10] Bäckström M, Karlsson S, Bäckman L, Folkeson L, Lind B. Water Res. 2004;38:720–732. DOI: 10.1016/j.waters.2003.11.006
[11] Findlay, S.E.G., Kelly, V.R. Ann NY Acad Sci 2011;1223(1):58-68. DOI: 10.1111/j.1749-6632.2010.05942.x.
[12] Chudecka J, Tomaszewicz T, Pacewicz K, Wróbel M. Fol Pomer Univ Technol Stetin. 2010;278(14):49-56.
[13] Brogowski Z, Czarnowska K, Chojnicki J, Pracz J, Zagórski Z. Soil Sci Ann. 2000;50(1/2):17-28. http://ssa.ptg.sggw.pl/files/artykuly/2000_51/2000_tom_51_nr_1-2/tom_51_nr_1-2_17-28.pdf.
[14] Li F, Zhang Y, Fan Z, Oh K. Bull Environ Contam Toxicol. 2015;94(4):25-531. DOI: 10.1007/s00128-015-1481-0.

WPŁYW KOMPOZYTU MIESZANKI WŁÓKIEN KOKOSOWYCH I SOLI STOSOWANYCH DO USUWANIA ŚLISKOŚCI JEZDNI NA GLEBY

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Abstrakt: Przedmiotem badań jest analiza wpływu zastosowanego kompozytu mieszanki włókna kokosowego i soli drogowej do usuwania śliskości drogowej na gleby w pasie przydrożnym. Badania laboratoryjne przeprowadzono na próbkach gleby pobranych z wyznaczonych poletek doświadczalnych w dwóch okresach: jesiennym przed zastosowaniem mieszanki oraz wiosną roku następnego. Analizy laboratoryjne wykazały głównie spadek wartości przewodnictwa właściwego po okresie zimowego stosowania zaproponowanego kompozytu, przyczyniając się do redukcji zasolenia gleb przydrożnych. Zastosowanie omawianej metody do usuwania śliskości jezdni może przyczynić się do zmniejszenia negatywnych skutków procesu zasolenia gleby w porównaniu z powszechnie stosowanymi technikami wykorzystującymi wyłącznie mieszanki samych soli.

Słowa kluczowe: zasolenie, usuwania śliskości drogowej, gleby przydrożne, włókna kokosowe, sole łatwo rozpuszczalne