7-5. Water quality – determination of long term toxicity of substances to Daphnia magna Straus (Cladocera, Crustacea): ISO 10706:2000. – [Publication date 2000-04]. – Geneva: International Organization for Standardization, 2000. – 17 p.

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## BIOTECHNOLOGIES FOR LIMITING THE EMISSION OF NITROGEN COMPOUNDS INTO WATERS FROM POINT AND NON-POINT SOURCES OF POLLUTION FROM AGRICULTURE

**INTRODUCTION.** One of the main causes of pollution of surface, underground and also coastal waters is the intensification of agricultural production. In 2012, as much as 45% of the total nitrogen load and 34% of the total phosphorus load discharged by rivers to the Baltic Sea came from Poland (HELCOM 2018). The main problems are surface and subsurface runoff from arable fields as well as improper management of animal manure. Leachate from unprotected sites of storing solid manure and leaking floors of livestock buildings often cause exceeded acceptable standards. Nitrogen from agricultural activity usually is emitted to the environment in nitrates ($NO_3^-$) and ammonia ($NH_3$) or in nitrogen peroxide ($N_2O$). In order to limit the negative effects of agriculture on the natural nitrogen cycle and on the environment, including ozone layer, water eutrophication, land acidification and biodiversity decline, a number of guidelines have been adopted, specifying direct action to minimize or prevent these effects (Galloway 2003). Counteracting the negative effects of excess nitrogen in the environment must be related not only to limiting the load of this element flowing into the basin from agricultural areas, but also with the possibility of accelerating the biodegradation of pollutants and binding them in the so-called a hard-to-reach pool (e.g. accumulation in plant tissues). In the case of nitrogen compounds, denitrification and nitrification processes play a key role in their transformations.

The aim of the work was to assess the use of denitrification deposits in the context of limiting the emission of nitrates to groundwater from point and diffused sources in rural areas

**METHODOLOGY AND RESULTS.** Two biotechnological solutions were used in the research to protect waters against point and non-point pollution from agricultural production: vertical deposits to protect waters against surface pollution and horizontal deposits for manure storage (Figures 1 and 2). The above technologies use the so-called denitrification deposits with a carbon substrate, constituting the basis for horizontal and vertical barriers (Bednarek et al., 2010, 2014). The deposits use the natural denitrification process with the participation of microorganisms. Denitrification bacteria, commonly found in the soil environment, reduce $NO_3$ to $N_2$, using carbon compounds as an electron acceptor for growth. These transformations can be presented as follows: $NO_3^-$ (V) → $NO_2$-(III) → NO (II) → $N_2O$ (I) → $N_2$ (0). In the leachates from manure dumps, $NO_3^-$ dominates. In the case of cattle the ammonium ($NH_4^+$) predominates. Nitrifying bacteria inhabiting the soil profile oxidize $NH_4^+$ to $NO_3^-$, and these in turn under appropriate conditions can be reduced by denitrification to molecular nitrogen ($N_2$), thanks to which the nitrogen cycle is closed without adverse effects on the environment.

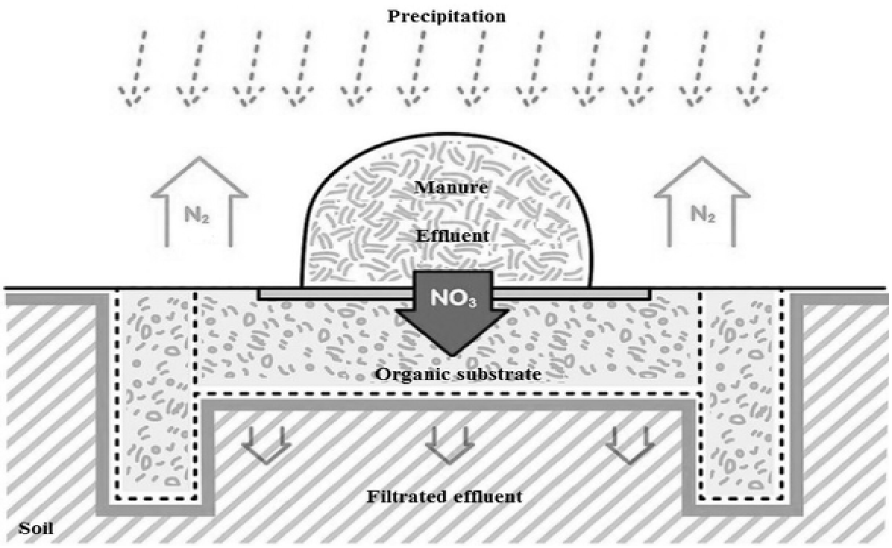


**Fig. 1. Horizontal denitrification deposit for manure storage sites**

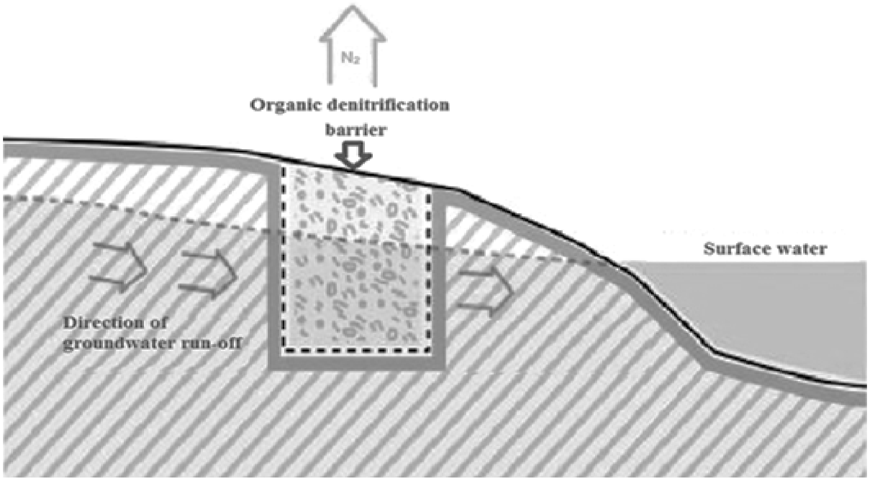


**Fig. 2. Vertical denitrification deposit as a barrier to the flow of groundwate contaminated with nitrates**

Denitrification process in catchment is one of few ways to remove excess of nitrogen from water environment. This process is responsible for 5-40% nitrogen transformation in the subsurface processes (Nikolenko et al., 2018) and optimal denitrification rate is the most important parameter in the nitrogen cycle (Chen et al., 2018). Efficient denitrification process requires carbon source for bacteria, beside optimal value of physical parameters like pH, temperature, dissolved oxygen (DO) and flow speed (or hydraulic retention time - HRT) (Soupir et al., 2018). Availability of carbon are the easiest factor to control in groundwater, moreover its management is at least neutral to the environment. Due research, in constructed deposits, processes of denitrification and nitrification were enhanced. The rate and effectiveness of natural denitrification depends on the type and availability of organic carbon in the soil, C:N ratio, species composition and the number of microorganisms and its activity in the transformation of nitrogen compounds. Example of denitrification rate depending of various organic materials which were used in the constructed and monitored deposits: lignite-brown coal, harl linseed, pine sawdust, barley straw, mix lignite&straw (Tab. 1). The deposits in this study were built on several farms in the province Lodz (Czarnocin, Tresta, Uniejow, Jerwonice) and Wielkopolska (Laszczyn). The constructed deposits were activated by composition of microorganisms involved in the transformation of nitrogen compounds (Mankiewicz et al., 2017).

**Table 1. The example of denitrification rate in selected individual deposits**

| Source of pollution | | Organic carbon substrate | Average nitrogen reduction [%] | The maximum nitrate load [mg $NO_3 \cdot dm^3$] | The maximum nitrate reduction [%] |
|---|---|---|---|---|---|
| Non-point | farmland | Harl flax | 50 | 90 | 88 |
| | farmland | Mix sawdust and straw | 22 | 98 | 59 |
| Point | cow manure | Brown coal | 65 | >2000 | 85 |
| | cow manure | Harl flax | 51 | 339 | 95 |
| | pig manure | Sawdus | 85 | 361 | 95 |

**CONCLUSIONS.** According to the spatial variation in nitrate reduction in groundwater in the Baltic Sea Basin (Højberg et al., 2017) implementation of denitrification walls in agricultural areas could be efficiency low cost nature based solution to protect groundwater and surface water quality, restrain eutrophication process and prevent algal blooms. Many research proved the efficiency of denitrification walls application for pure area pollution near river or lakes shores. Our results indicated that the use of DWs in agricultural landscape could be extend for identified hot spot pollution sources like manure storage places. The highest denitrification effect was observed at ditches constructed around the storage manure, due spring and autumn period (even above 95% of nitrogen reduction). Moreover it seems that DWs are applicable to reduce both nitrates and ammonium pollution, which could difference between the types of animal manure.

Carbone source added to denitrification walls and other barriers was important component which improve natural purification process occur in water, but to increase Denitrification deposits efficiency, especially in high contaminated places there is need to investigate well hydrological dynamic in construction places to provide high reduction of nitrogen pollution.

These biotechnology seems to be the alternative solutions for the concrete manure plates. It is important to use easily-obtained, locally-available carbon-rich materials to minimize transport costs. Microbial activators accelerate the activation of the deposit and support its functioning after a period of drought or heavy rains.

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**REFERENCES**

1. Bednarek, A., Szklarek, S., Zalewski, M. 2014. Nitrogen pollution removal from areas of intensive farming – comparison of various denitrification biotechnologies. Ecohydrology & Hydrobiology 14: 132–141. http://dx.doi.org/10.1016/j.ecohyd.2014.01.005
2. Bednarek, A., Stolarska, M., Ubraniak, M., Zalewski, M., 2010. Application of permeable reactive barrier for reduction of nitrogen load in the agricultural areas – preliminary results. Ecohydrol. Hydrobiol. 10 (2– 4), 355–362. DOI: 10.2478/v10104-011-0007-6
3. Chen, Z., Shi, L., Ye, M., Zhu, Y., Yang, J. 2018. Global sensitivity analysis for identifying important parameters of nitrogen nitrification and denitrification under model uncertainty and scenario uncertainty. Journal of Hydrology, 561: 884-895. https://doi.org/10.1016/j.jhydrol.2018.04.031
4. Galloway J.N., Dentener F.J. Capone D.G., Boyer E.W., Howarth R.W., Seitzinger S.P., Asner G.P., Cleveland C., Green P., Holland E., Karl D. M., Michaels A. F., Porter J. H., Townsend A., Vőrősmarty C. 2003. Nitrogen Cycles: Past, Present and Future. Biogeochemistry.
5. HELCOM. 2018. Sources and pathways of nutrients to the Baltic Sea. Baltic Sea Environmental Proceedings No. 153
6. Højberg, A.L., Hansen, A.L., Wachniew, P., Żurek, A.J., Virtanen, S., Arustine, J., Str□mqvist, J., Rankinen, K., Refsgaard, J.Ch. 2017. Review and assessment of nitrate reduction in the groundwater in the Baltic Sea Basin. Journal of Hydrology: Regional Studies 12: 50-68. https://doi.org/10.1016/j.ejrh.2017.04.001
7. Mankiewicz-Boczek, J., Bednarek, A., Gągała-Borowska, I., Serwecińska, L., Zaborowski, A., Kolate, E., Pawełczyk, J., Żaczek, A., Dziadek, J., Zalewski, M. 2017. The removal of nitro gen compounds from farming wastewater – The effect of different carbon substrates and different microbial activators. Ecological Engineering, 105: 341-354.
8. Nikolenko, O., Jurado, A., Borges, A.V., Kneller, K., Brouyère, S. 2018. Isotopic composition of nitrogen species in groundwater under agricultural areas: A review. Science of the Total Environemnt, 621: 1415-132. https://doi.org/10.1016/j.scitotenv.2017.10.086
9. Soupir, M.L., Hoover, N.L., Moorman, T.B., Law, J.L., Bearson, B.L. 2018. Impact of temperature and hydraulic retention time on pathogen and nutrient removal in woodchip bioreactors. Ecological Engineering, 112: 153-157. https://doi.org/10.1016/j.ecoleng.2017.12.005

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## ПЕРЕРОЗПОДІЛ РАДІОНУКЛІДІВ У ЕЛЕМЕНТАХ АГРОЛАНДШАФТІВ РІЗНИХ ТИПІВ ПОЛІССЯ УКРАЇНИ

*Проаналізовано та виділено основні агроландшафти Українського Полісся. Графічно формалізовано модель перерозподілу радіонуклідів у елементах агроландшафтів різних типів досліджуваного регіону. Визначено та проаналізовано основні чинники, які впливають на перерозподіл радіонуклідів у елементах екосистем. Проаналізовано перерозподіл радіонуклідів у критичних екосистемах Українського Полісся та графічно формалізовано моделі міграції радіонуклідів у цих екосистемах.*

**Ключові слова**: агроландшафт, радіонукліди, графічна модель, Полісся.

Проблема радіоактивного забруднення сільськогосподарської продукції на території Полісся України набуває певних особливостей, характерних саме для віддаленого періоду після аварії на Чорнобильській АЕС. У контексті сучасної радіоекологічної ситуації доцільним є аналіз питання радіоактивного забруднення не в межах окремих екосистем, а в межах ландшафтів. Тому постала очевидна необхідність перегляду і актуалізації характеристик та особливостей перерозподілу радіонуклідів елементами різних типів агроландшафтів. Даній тематиці присвячено окремі роботи вітчизняних [3] і закордонних науковців [4], однак більшість із них зазвичай застаріла і приурочена до адміністративних територій, переважно населених пунктів, щонайбільше невеликих районів. Також все більшої уваги набуває питання комплексної реабілітації регіону Українського Полісся.