

Utilization of urban sewage waters for irrigation of agricultural lands in Ukraine

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SUMMARY

The research results of ecological passportization for the municipal treatment facilities sewage disposals were presented (its chemical composition and sanitary measurements). There were determined the availability of the sewage disposals for irrigation and the prospects of use in agriculture.

Keywords: *sewage disposals, quality and quantity of the sewage disposals, sewage disposals groups by the level of availability for the irrigation, the prospects of use for irrigating fields*

ISSUE

In the late 1980's, the irrigated agricultural fields designed for utilization of sewage waters from urban sewage disposal plants occupied over 70 th. ha in Ukraine. The largest areas of them were concentrated in the Kyiv, Kharkiv, Dnipropetrovsk, Donetsk, Luhansk, Odesa regions, as well as in the Crimean Autonomous Republic. However, due to a number of reasons, the efficiency of sewage water industrial treatment has considerably declined over the past decade, the operation of specialized irrigation systems (including the most perfect among them, Bortnytska, with an area of 22.6 th. ha) has been suspended that resulted in a considerable man-made pollution of natural water ecosystems and aggravated the socio-economic situation in the country. An alternative to the discharging of waste waters into water bodies is their reuse for irrigation of agricultural fields.

MATERIALS AND METHODS

Thereby we studied the quality and quantity of urban sewage disposals (from cities with a population over 30 thousand) during pre-crisis period of social production and determined prospects for use of municipal treatment facilities sewage disposals for irrigating fields in different soil and climatic zones of the country. The calculation of possible areas under sewage-irrigated agricultural fields was made by the standard method (VSN 33-2.2.02-86, 1986) with taking into account the seasonal need in sewage waters. Here we present summarized results of this research [see the publications (Dyshlyuk, 1997, 1998) for more details].

RESULTS

It was established that sewage waters of municipal treatment plants in the Zakarpattia, Lviv, Ivano-Frankivsk and Chernivtsi regions are alkaline and alkaline (pH 7.5–8.3), contain salts of chloride-hydrocarbonate-calcium-sodium content, and are slightly mineralized (0.5–0.9 g l⁻¹). Their content of chlorides and sodium ions does not exceed the level of maximum allowable concentrations (MAC) established for irrigation of different soil types. These waters are characterized by

insignificant values of BOD₅ (biochemical oxygen demand) (6.0–25.0 mg O₂ l⁻¹), COD (chemical oxygen demand) (27.2–70.0 mg O₂ l⁻¹), suspended matters (9.9–26.0 mg l⁻¹), and gross and mobile forms of nutrients. The concentrations of oil products, SSAM (synthetic surface-active materials), heavy metal salts in the outflows do not exceed the MAC levels. No phenols were found in their content. According to results of the irrigation-related evaluation, sewage waters of Uzhhorod, Mukachiv and Lviv are quite suitable for land irrigation, outflows of other cities can be used for watering after chemical conditioning.

Our calculations show that 321.9 mln. m³ of sewage waters, suitable for irrigation, are generated annually at sewage disposal plants of cities in the Carpathian Foothills. In case of need, they can be used for watering of 214 th. ha of agricultural lands. Proceeding from volumes and qualitative content of sewage waters, the largest areas in this part of Ukraine can be irrigated in the Lviv region (138 th. ha).

Sewage waters of municipal treatment plants in the Forest zone (the Volyn, Rivne, Zhytomyr and Chernihiv regions) are characterized by alkaline and alkaline (pH 7.2–8.2) medium, salinity equaling 0.6–0.9 g l⁻¹, hydrocarbonate-sodium content of salts. Outflows of sewage disposal plants of individual cities (Rivne, Nizhyn) have an increased salinity (1.1–1.2 g l⁻¹). Sewage waters in the Forest zone do not exceed the established MAC levels by their content of chlorides and sodium ions, and may be applied to irrigation of different soil types. The gross content of nutrients in the outflows range within such limits: nitrogen – 11–28, phosphorus – 3–25, potassium – 11–52 mg l⁻¹. By the physicochemical indicators: BOD₅ – 2156 mg O₂ l⁻¹, COD – 40–439 mg O₂ l⁻¹, amount of suspended matters – 7–184 mg l⁻¹ as well as by content of specific matters, particularly SSAM – 0.2–0.7 mg l⁻¹ and oil products – 1.2–25.0 mg l⁻¹, the sewage waters are found within the limits of allowable concentrations. Phenols were not detected in the outflows. There was registered some exceeding of the MAC level by chrome (Kovel) and fluorine (Rivne) contents. So, proceeding from the results of the irrigation-related evaluation of urban sewage waters in the Forest zone, these waters are suitable for irrigation. However, according to results of an evaluation using the strictest, M.F. Budanov's,

method, sewage waters of Chernihiv, Nizhyn, Novohrad-Volynskiy, Rivne and Kovel belong to the category of restrictedly suitable and need certain conditioning for subsequent irrigation.

In the Forest zone the volumes of sewage waters treated at respective sewage disposal plants total 185.6 mln. m³ annually. Such an amount of them is sufficient for irrigation of 124 th. ha of land. According to calculations, sewage waters generated by cities of the Zhytomyr region alone can irrigate an area of 37 th. ha. After previous conditioning, these waters are quite suitable for irrigation of fields in the Rivne (27 th. ha) and Chernihiv (33 th. ha) regions.

Properly prepared urban sewage waters of the northern and south-western Forest-Steppe (the Kyiv, Ternopil, Khmelnytskyi and Vinnytsia regions) have alkaline medium (pH 7.2–7.9), hydrocarbonate-calcium content of salts, and salinity 0.4–1.0 g l⁻¹. They contain comparatively low amount of ions of sodium (40–195 mg l⁻¹) and chlorine (64–185 mg l⁻¹). This enables their use for watering on sod-podzol, grey forest soils and chernozems (black earths). The sewage waters do not exceed allowable concentrations by physicochemical indicators – BCD5 (3–6 mg O₂ l⁻¹), suspended matters (10–150 mg l⁻¹), and others. Judging from the irrigation-related evaluation of the region's sewage waters, which was carried out applying different methods, these waters are quite suitable for irrigation, except for individual cities (Bila Tserkva, Brovary, Ternopil and Khmelnytskyi), outflows of which need additional water preparation.

Sewage waters of the south-eastern part of the Forest-Steppe (the Cherkasy, Poltava, Sumy and Kharkiv regions) have alkaline (pH 7.2–7.9) medium reaction, hydrocarbonate-sodium and hydrocarbonate-calcium salts, and salinity 0.8–1.2 g l⁻¹. At the same time, sewage waters of the Poltava region's cities (except for Kremenchuk) are characterized by increased salinity (1.9–2.2 g l⁻¹), they exceed the MAC level by content of ions of chlorine (in 1.9–2.0 times) and sodium (in 1.2–2.5 times), and cannot be used for irrigation of chernozems. Judging from data of the irrigation-related evaluation, sewage waters of the region on the whole are suitable for land irrigation, except for those of the cities of Poltava, Myrhorod and Lubny (the Poltava region), which are restrictedly and conditionally suitable for irrigation. To prevent soil alkalization processes, previous preparation is required for sewage waters of the cities of Uman, Smila, Kremenchuk, Kharkiv and Merefá.

1320.4 mln. m³ of urban sewage waters, sufficient for irrigation of 550 th. ha, are annually generated in the Forest-Steppe zone. Due to considerable volumes of the Group 1 sewage waters available in this zone (1199 mln. m³ year⁻¹), 499 th. ha of lands can be irrigated without extra costs on water preparation. In the northern part of the Forest-Steppe, the utilization of sewage waters for irrigation is most promising in the Kyiv region; in the south-eastern part – in the Cherkasy, Sumy and Kharkiv regions; in the south-western part – in the Vinnytsia and Khmelnytskyi regions.

Studies conducted in the Steppe zone indicate that urban sewage waters of the Dnieper cities (the Kirovohrad,

Dnipropetrovsk and Zaporizhzhia regions) are alkaline (pH 7.4–8.0), have hydrocarbonate-sodium-calcium content of salts and low salinity (0.4–0.6 g l⁻¹). An exception are sewage waters of Olexandria, Kryvyi Rih, Pavlohrad and Melitopol, salinity of which reaches 0.7–1.2 g l⁻¹. According to results of the investigation, sewage waters of this territory (except for Melitopol) can be used for irrigation of chernozems. The contents of BOD₅ (2.5–77.5 mg O₂ l⁻¹) and suspended matters (1.0–150 mg l⁻¹) are not high. The concentrations of oil products, SSAM, nitrates, heavy metal salts chiefly do not exceed the MAC levels. According to results of the irrigation-related evaluation, sewage waters of the majority of treatment plants of the Dnieper cities (except for Melitopol) are suitable for irrigation of lands. Sewage waters of the cities of Kirovohrad, Olexandria, Pavlohrad, Dniprodzerzhynsk, Kryvyi Rih are categorized as restrictedly suitable, therefore, chemical meliorants should be used while applying them on dark-chestnut and chestnut soils.

In the Black Sea cities (the Odesa, Mykolaiv, Kherson regions and the Autonomous Republic of Crimea) sewage waters have alkaline and alkaline medium reaction (pH 7.1–8.3), hydrocarbonate-sodium and chloride-hydrocarbonate-sodium content of salts, increased salinity (1.3–2.2 g l⁻¹). The waters arriving from sewage disposal plants of Kherson, Mykolaiv, Odesa, Bilhorod-Dnistrovskiy, Kerch, Sevastopol, Yevpatoria, Jankoy and Armiansk contain increased or large amounts of ions of both chlorine and sodium, which exceed the MAC level established for irrigation of chernozems and chestnut soils. These waters mainly do not exceed the MAC level by physicochemical indicators, contain insignificant amount of nitrites, SSAM, oil products. By results of the irrigative evaluation, urban sewage waters of the Black Sea area are mostly ranked as restrictedly suitable, and waters of individual towns of the Odesa region (Bilhorod-Dnistrovskiy) and the Crimean Republic (Kerch) – as conditionally suitable for irrigation.

In the Steppe zone, the volumes of sewage waters suitable for irrigation total 1656.3 mln. m³ year⁻¹ and, as calculated, may be used for irrigation of 526 th. ha of lands. In the northern Steppe sub-zone, most promising is their utilization for irrigation in the Dnipropetrovsk region, where there is concentrated the most part of the Group 1 urban sewage waters (693 mln. m³ year⁻¹) in this sub-zone. In the southern Steppe sub-zone, sewage waters by qualitative indexes belong mostly to the Groups 2 and 3, however, the resources of the Group 1 sewage waters in the Zaporizhzhia region and the Crimean Autonomous Republic create an opportunity to water 65 and 40 th. ha, accordingly, without extra preparation costs. The irrigated areas can be essentially expanded (by 142 th. ha) at the expense of using previously prepared sewage waters of the Group 2 (469 mln. m³ year⁻¹) from cities of the Odesa, Mykolaiv, Kherson and Zaporizhzhia regions and Crimea.

Therefore, the capacity of prepared sewage disposals in the treatment facilities is sufficient for irrigating the 1 million hectares of lands (Dyshlyuk, 2009).

In closing, it is worth noting that the highly efficient and safe utilization of sewage waters on sewage-irrigated agricultural fields is possible after introduction of up-to-date special technologies of their use (Dyshlyuk, 2009; VND 33-3.3-01-98, 1998), which provide for a system of activities for sewage water preparation, implementing special crop rotations, resource-saving modes and methods of irrigation, measures on conserving and raising of soil fertility, nature-protection measures, etc. Introduction of present-day technologies and their separate elements in a number of farms of the Forest-Steppe and Steppe zones allowed to obtain a considerable environmental and economic effect (Dyshlyuk, 2009; Beskrovny et al., 1989).

CONCLUSIONS

Biologically treated urban sewage waters can be an important reserve for development of irrigated agriculture in Ukraine. Judging from quantitative and qualitative indicators of sewage waters, soil-climatic conditions, etc., most promising for development of irrigation with urban waste waters are the Forest-Steppe and Steppe zones. A high level of environmental and economic efficiency of sewage waters utilization on sewage-irrigated fields can be achieved provided that up-to-date scientifically-grounded technologies are introduced.

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