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Use of Micro-Irrigation to Irrigate with Purified Waste Water

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Abstract

Experiences gained by use of purified wastewater for microirrigation are presented in this paper. Microirrigation with wastewater is distinguished by favourable cleaning effect, high degree of use of water and corresponding protection of environment. Within the framework of our research inquiries we aimed at the device for finalisation of cleaning wastewater by sieve filters with floating refills made from foamed polystyrene and polyurethane. We recommended simple device for disinfection of water by UV rays, testing of suitable types of discharge equipment and worked out programme methods for proposing irrigation lines for point irrigation, drip irrigation and microsprays. In the process of finding out cleaning effect of soil in micro-irrigation we found out cleaning effects exceeding values obtained with classical irrigation of medium spray and irrigation by flooding and outlets.

Keywords: *Micro irrigation, wastewater, environment, micro spray etc.*

INTRODUCTION

Irrigation with wastewater belongs to the category of natural methods of cleaning. In wastewater irrigation we use water and fertiliser values of wastewater at the same time cleaning the water in the soil environment. Natural methods of cleaning wastewater are used in nature by self-cleaning processes of wastewater. Vegetation takes active part in the cleaning process, especially by creating favourable conditions for development of micro-organisms, using water and releasing vegetative nourishment, especially nitrogen, phosphorus and potassium to create biomass and by that to increase production of agricultural crops.

Filtration in porous environment can absorb most of the organic materials, which later contribute to increase in the content of humus in soil. Cleaning effect of soil is influenced not only by composition of soil, quality, and extent of physio-chemical, chemical and biological processes but also by the method of irrigation employed. Through irrigation we aim at increasing the yield of agricultural crops significantly. Irrigation is one of the rarest economic methods of cleaning wastewater with high cleaning effect of the soil environment. In irrigation with purified wastewater, we use all the irrigation methods viz. spray, subsurface, flooding, outlet and microirrigation. Each of these methods has its own specific particularity, priority but very little disadvantages. Use of microirrigation (especially point irrigation, drip irrigation and microsprays) is not widespread in this country and is not very much investigated upon.

USE OF MICROIRRIGATION TO IRRIGATE WITH COMMUNITY WASTE WATER

Use of micro irrigation to irrigate with community waste water has plenty of significant advantages over the other methods, such as the following:

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1. Uniform and very gradual distribution of water in irrigated fields.
2. In microspray the wastewater is perfectly oxidised and divided at the surface level.
3. In locations of discharge devices and shallow droppers under the terrain, it does not interfere with the working of the operators.
4. Slow infiltration of water through unsaturated oxidised soil environment enables aerobic breakdown, speed up mineralisation of organic parts and releases nutrients.
5. Microirrigation creates zones of capillary suspension of water and does not allow contamination of water.
6. Microirrigation is possible to be fully automated and thus excludes direct dealing by service personnel.
7. Negative influence of wind on point and drip irrigation does not manifest.
8. Irrigation with wastewater irrigates only the root zone of the plants, while the surrounding areas remain free from wastewater.

In use of micro irrigation it is necessary to clean community wastewater (sewage) in necessary cases, disinfect, keep protection limit between last irrigation and harvest (Table 1) and observe protective distances (belt/strip) from residential complexes, communication systems, sources of drinking water etc. Breadth of protection belts in point and drip irrigation is considerably smaller than in irrigation through sprays and makes use of only one fifth of total water. It is suitable to irrigate light and medium soils and unsuitable for extremely light (sandy soils) and extremely hard/dense soils (clay).

Table 1. *Protection of limit between last irrigation and harvested (grazed) cultivated produce*

Produce	Allowable wastewater sanitation	Introduction of wastewater sanitation
Used timber	Without restriction	2 months before output
Sugar beat, industrial potato, fibre plants	Without restriction	Up to 14 days before harvest
Feed beat, semi sugar beat, potato, corn	Up to 7 days before harvest	Up to 21 days before harvest
Temporary and permanent meadow, pasture and forage on arable land	7 days before harvest or grazing	21 days before harvest or grazing
Vegetables used in boiled state (red beat, spinach, aubergine)	7 days before harvest	21 days before harvest (in irrigation with all methods, in the period of vegetation except micro spray irrigation)
Used vegetables in fresh state (strawberry)	Up to 14 days before harvest	Not permitted, except subsurface irrigation and in the extra-vegetative period
Fruit trees and shrubs, ornamental plants	Up to 14 days before harvest	Not permitted except subsurface irrigation and in the extra-vegetative period

Note: In sub-surface irrigation in field plants it is not necessary to protect limit

Degree of Cleaning of Waste Water

The needed degree of cleaning of wastewater is dependent on types and arrangement of micro-irrigation, such as:

1. For point irrigation and microspray it is necessary to have minimum mechanical cleaning of community water, which constructed with bar screens, sand catch, fat and settlement basin and smooth sieve filter with holes of size ranging from $1/5^{th}$ to $1/7^{th}$ of average highest size of impurity.
2. For drip irrigation and disinfection with UV rays it is necessary to have mechanically and biologically cleaned

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(activation, biofiltration, and biological process) and smooth filtration.

Wastewater used for irrigation must not contain toxic materials in amount exceeding limits of toxicity and this is connected with the selection of suitable produce, irrigation regime, technically arranged irrigation, selection of protective belts around irrigated fields and fixing of protection limits between last irrigation and harvest. This requires high degree of cleaning, proper method of protecting atmosphere, surface and sub-surface water and total protection of environment.

As part of the study, a simple disinfecting device was developed that uses UV rays for disinfection of mechanically and biologically cleaned wastewater. The device consists of a stainless steel oven with a Silicon tube in the centre with an UV tube-light with optimum wavelength of 253.7 nm. The period of exposure is chosen depending upon the kind of micro-organism, which is needed to be removed. A film is put in front of the device that contains a float filled with smooth polyurethane, which catches the smooth flakes released from the extended basin behind the activator. There is a slow moving wiper device that removes pollutants around the Silicon pipe.

DEVICE FOR FILTERING WASTEWATER BEFORE ITS USE FOR MICROIRRIGATION

Filters are used mainly for trapping flakes from mechanically and biologically cleaned water before disinfection by UV rays and for their use in drip irrigation. Usually un-pressurised and pressurised sand filters of various kinds and construction arrangements are used for this purpose. Other possibilities were searched and for this purpose the following two constructions were chosen:

a) Pressure filter with refill from foamed material with different construction arrangement.
b) Un-pressurised and pressurised filters with floating refill from granulated polystyrene.

First group creates ring filters with refill from polyurethane disks having thickness of 100 mm, outer average of 1000 mm with opening of about 250 mm. Prepared water is fed centrally and it filters into the lateral walls and outflows upwards to the small accumulating area from where it is used at the washing filter. For supply, the pipe is located in a fast-closing cock, which cyclically releases water. Need of washing water is about 3% of total filtered amount. Similar solution is the filter presented in Fig.1. Filtering is performed by the polyurethane filtering pipelines (3) planted at the sieve grate, fixed at the bottom (Fig.1). Accumulating space (5) for prepared water is located above the bottom of the mouth-pipe. Filter with float (Fig.2) is certified as un-pressurised and pressurised with maximum operating pressure of 0.25 to 3.0 MPa (In high pressure we found out deformation of granules). Filtering environment creates foam of polystyrene (3) of average size of 1 to 3 mm, located in rolling vessel. In the middle portion is located the sieve (4) that prevents floating filter media. Orifice is in the lower part of the basin (1), which at the same time creates sediment space. Above the central bottom is the accumulating space (2) with arranged washing of water. Filtering velocity is about 1mm/sec. Filter refills gradually choke up and increases filtering resistance. On reaching limiting value the supply of filtered water is closed and outflow of wastewater and water from accumulating space with filter wash commence. Water needed for this purpose is about 2%.

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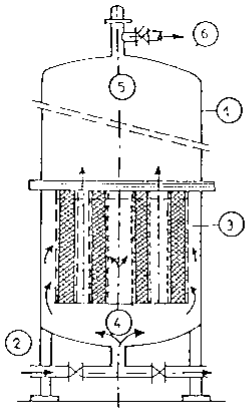

Fig 1 *Schematic representation of pressurised filter*

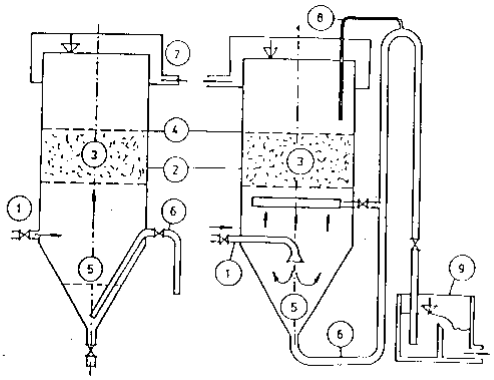

Fig 2 *Schematic representation of filter with filled-in float*

Both types of filters can perform mechanical and biological cleaning of wastewater. Relatively good results were obtained also with the use of slow un-pressurised filters with refill made from Silicon sand of about 0.2 to 0.4 mm with a power head of 0.8 to 1.2 m and speed of filtration of 2.5 to 4.0 m/day. A biological membrane is created on the surface filter, which catches the important parts of microorganisms.

For performing mechanical cleaning of wastewater before its use for point irrigation we developed simple un-pressurised and pressurised sieve filters. Un-pressurised filters are made from drum sieve located in open basin. In this case water flows from outside to inside and also from inside of drum sieve to outside. Mechanical cleaning of wastewater through sieve also results in cleaning the water from small dirt. A part of the net creates difference of levels with a height from 0.2 to 0.4 m and as a result the flushing device starts and the net drum is revolved. At the same time the spraying device prevents pollutants to get trapped on the net. Electro-motor, hydro-motor, water turbine built in supply line of water can be used to drive the drum net. The construction of pressure filters and their arrangement are shown in Figure 1. Instead of blower mouth made from polyurethane we can also use net.

ARRANGEMENT OF MICROIRRIGATION

We paid utmost attention to point irrigation as micro irrigation. While performing the mechanical cleaning of community wastewater we used mostly point irrigation and very less drip irrigation and micro spray. Point irrigation results in slow discharge of water from the discharge device, which consists of the following:

1. Drilled outflow holes, specially drilled to the size of about 1 to 3 mm
2. Planned outflow holes of about 1 to 3 mm
3. Special discharge destroyer of size 0.8 to 2.0 mm
4. Special discharge device with cleaning needle of about 1 to 3 mm (Fig. 3)

Capacity of discharge device, Q is calculated from the relation

$$\mathbf{Q = \mu S \sqrt{2gH}}$$

where,
μ = Discharge parameter
S = Area of cross-section of discharge device, m^2
H = Pressure head, m

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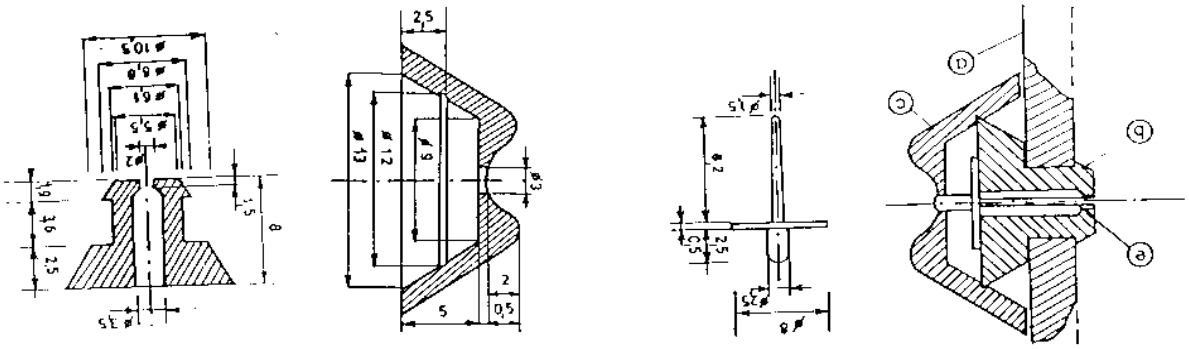
Values of discharge parameter μ were found out experimentally from the series as 0.63, 0.87, 0.93 etc

Arrangement of special discharge device with cleaning needle Zvolex is presented in Fig. 3. Cleaning needle is possible to be loosened in case dirt influences outflow. In this paper nomograms are not included. The cover protects the discharge device against external pollutants.



a- Polyethylene pipe, **b**- Cover, **c**- Discharge muzzle, **e**- Cleaning needle

Fig 3 *Schematic representation of discharge device*

A wide range of dimensions of discharge devices enable exact dimensioning of irrigation (divider pipelines) and uniform division of irrigation water. Irrigation pipelines are laid down on the surface of irrigated area or at shallow depth under the surface. Subsurface irrigation has many advantages; most important is elimination of contact between service personnels and waste water.

With the use of drippers there were no problems when mechanically and biologically cleaned wastewater was used with suitable cleaning filter.

CLEANING EFFECT IN IRRIGATED WASTEWATER

In rightly designed irrigation regimes micro-irrigation with wastewater does not result in surface and groundwater discharge and also in contamination of surface and subsurface water. For this purpose we overloaded soil profiles of loamy soil with high irrigation dosage. From the results it follows that cleaning effect reduces coherence with height of soil profile (Table 2)

Table 2 *Cleaning effect of loamy soil (%) in filtration with mechanically cleaned wastewater*

Component	Depth of soil profile, m		
	0.25	**0.70**	**1.20**
Total nitrogen	75.0	85.8	88.2
Ammonium nitrate	90.5	98.1	100.0
Calcium	-1.8	5.8	28.5
Magnesium	-9.4	-16.3	-103.0
Potassium	60.7	86.1	93.8
Phosphorus	91.7	100.0	100.0
BSK_5	96.8	100.0	100.0
CHSK (Chromium)	80.1	86.5	97.5
Escherichia Coli	99.1	100.0	100.0

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SUB-SURFACE MICROIRRIGATION WITH WASTEWATER

Advantage of sub-surface irrigation is minimum of interference of service personnel with the irrigation equipment with wastewater, which from the standpoint of hygiene enables almost unrestricted use of wastewater with possibility of full atomisation of operation. Further, irrigation equipment does not influence management at the irrigation fields and water and nutrients are received directly at the root zone of irrigated plants.

Separation of irrigation pipelines and single discharge devices can be proposed in a similar manner, like in irrigation with clear water. In this case spacing of irrigation pipelines ranges from 1.0 to 2.5 m depending upon the type of soil and its hydraulic conductivity, while the depth of placing of irrigation line varies from 0.35 to 0.40 m. This arrangement was tested. Course of moisture movement in very light loamy sand and in deep (almost non-transmitting) soil is presented in Fig. 4.

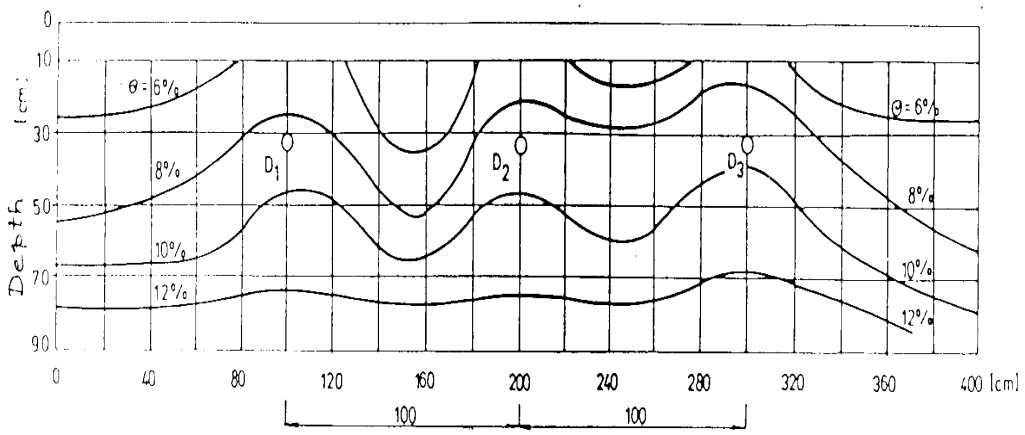

Fig 4 *Course of moisture movement in light soil*

The size of irrigation dosage was intentionally doubled so as to find out the process of cleaning of wastewater in soil environment with sand, sandy loam and loamy soil. Filtering water was collected in depth of 1.1 m. Cleaning effect of soil was 56.8-80.9-85.2 %, 64.4-87.7-93.7%, 96.3-98.3-99.9% and above 98% in case of CHSK (Cr), BSK_5, Ammonia and Phosphorous respectively. First values are for sandy soils, second for sandy loam soils and the third for loamy soils. From the results it follows that in overloading wastewater and relatively small filtering distance of 0.7 m the cleaning effect of sandy loam and loamy soil is good. Intensive irrigation results in deposition of Calcium, Magnesium and Nitrates if these are not used by plants.

CONCLUSION

From the results obtained it can be concluded that the possibility of using microirrigation to irrigate with clean community wastewater is immense and results can be positive. For cleaning wastewater we fabricated simple filters and proposed methods to disinfect mechanically and biologically cleaned wastewater and also examined the discharge devices. We tested the method of sub-surface point irrigation. Achieving cleaning effect of sandy loam to loamy soil by this method of irrigation is comparable with very good functional artificial methods of cleaning. In soil it results in almost 100% holding of nitrate and phosphorus.

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