Technological solution for wastewater treatment of the machinery plant

E Gogina
Moscow State University of Civil Engineering (National Research University), 129337 Moscow, Russia
goginaes@mgsu.ru

Abstract. The paper describes a solution for wastewater treatment of a tractor plant in Russia. The amount of wastewaters from the plant is 4861 m³/day. Various options for the recirculation of pre-purified effluents from different shops of the tractor plant are considered. To develop a rational scheme of wastewater disposal and assess the possibility of reusing the industrial wastewater, the composition and mode of wastewater disposal are studied. Technological schemes of four local wastewater treatment plants (LWTP) with mechanical, physical, and chemical methods are applied to reuse water for production processes. The solution for the purification of storm water is also provided with its reuse for industry. Total water reuse is about 49.7% of water needs for the plant.

1. Introduction
In each industrial plant there is a complex of drainage networks and structures. Some remove the wastewaters from the territory of the plant (if their further usage is impossible on specifications, or it is inexpedient on technical and economic indicators). Others are meant for sewage treatment and extraction of valuable substances and impurities from them, or for the water reuse for needs of the plant. To develop a rational scheme of wastewater disposal and assess the possibility of reusing industrial wastewater, the composition and mode of wastewater disposal are studied. At the same time, the physico-chemical characteristics of wastewater and flow in the drainage network are analysed not only for the total flow of industrial plant, but also for the individual departments and, if necessary, for a separate apparatus.

Tractor plant is a complex manufacture consisting of several departments and administrative buildings within its territory. Thus, it is necessary to determine the characteristics of processes in each department as well as the amount and characteristics of wastewaters from each technological process and to decide the further approach to the treatment, if possible, with the water reuse cycles. The plant consists of the following shops: 1) foundry of nonferrous and ferrous metallurgy, 2) shop of mechanical operation of details, 3) units assembly shop, 4) assembly line, 5) shop of testing and debugging 6) shop of non-metal fabrication production, and 7) galvanizing shop. The amount of wastewaters from the plant is 4861 m³/day.

2. Methods
In order to determine the technological solution for the treatment of the plant effluent, we should estimate the characteristics of effluent from each shop of the plant. After the analysis, four groups of industrial wastewaters have been indicated.
1) Non-polluted waters from the cooling equipment, constituting 50-80% of the total amount of water used in the plant. They are removed from the compressor units, boilers, electric foundry furnaces, units for tempering with high-frequency currents, and other shops, as well as after cooling in cooling towers or splash pools. These waters should be sent to the water recycling system.

![Water balance scheme of the machinery plant](image)

**Figure 1.** Water balance scheme of the machinery plant.

2) Wastewaters with mechanical impurities and oils. These wastewaters come from washing products in the mechanical assembly, forging, welding, and other industries. They make up about 10-15% of the total amount of water used, being similar in composition to rainwater, melt runoff, and runoff from irrigation areas.

3) Concentrated oily wastes, which are produced in mechanical assembly and galvanic shops, in the areas of metal plating and colouring, degreasing and cleaning products where lubricating fluids, emulsions, detergents, and degreasing solutions are used.

4) Chemically weakly polluted wastes, which are produced from washing products in the preparation for varnishing and heat treatment of metal; concentrated chemically contaminated water from galvanic production and from the preparation of products for varnishing. They include also the mineralized waters produced from the chemical water treatment units.

3. Results
To reach the optimal treatment of industrial wastewaters, four local wastewaters treatment plants (LWTP) and an industrial treatment plant have been designed.

3.1. Wastewater treatment technology of LWTP 1
The plant is designed for wastewaters from the foundry of non-ferrous and ferrous metallurgy. These waters belong to the second group – waters contaminated with mechanical impurities. The main type of pollutant containing in waters after the shop of non-ferrous and ferrous metallurgy is scale. In the
technological scheme, vertical flow sedimentation tanks are chosen, the sludge then proceeds to the sludge densifier, and then is removed to the deposit tip.

![Figure 2](image2.png)

**Figure 2.** Technological scheme of LWTP 1.

### 3.2. Wastewater treatment technology of LWTP 2

Here, the wastewaters related to the discharge lubricating fluid are processed. These waters are recommended to be subjected to a local electrochemical purification in the following technological scheme: 1) preliminary sedimentation, and the homogenization of the flow, 2) removing sediment and free oils, 3) acidification to pH = 6.5, 4) treatment with electrolysis for removing foam and slurry; 5) additional settling, and 6) filtering. Purified water in a mixture with tap water (in a ratio of 1:1) can be reused for the preparation of fresh emulsions, as they are stable, withstand corrosion test, and have a microbiological susceptibility of 0 points.

![Figure 3](image3.png)

**Figure 3.** Technological scheme of LWTP 2.

### 3.3. Wastewater treatment technology of LWTP 3

Wastewaters of electroplating industries are the most dangerous in terms of toxicity, because they contain highly toxic ingredients in the form of heavy metals. Chemical and electrochemical product processing is the main source of pollution of sewage from electroplating productions. The ion exchanger unit of cyclic action is accepted. The process of treatment consists of several steps. Firstly, the waters face the mechanical filter of preliminary filtration. Then the water goes to the cation exchanger, where all the free cations and hydrogen ions have an exchange. The next stage is slightly alkaline aminoalkenes, in which there is an exchange among all anions of slightly dissociated acids and hydroxyl ions. The ability of ion exchange resins to absorb is limited, thus they go through the
cycle of regeneration for cation exchanger with hydrochloric acid and the matrix of sodium hydroxide for anion exchangers. The process of removing chromates is as follows: the pH value is set by adding an acid or alkali of about 2.5. Finally, depending on the oxidation-reduction potential, sodium bisulfite is added.

Being purified from chromate, acidic effluents are previously neutralized by adding a caustic soda solution to reach a pH of 5.5-6.0. The next step is neutralization by adding milk of lime to achieve a pH of 9-9.5. After neutralization, the drains are completely at rest for about 2 hours. During this time, the bottom of the tank – reactor sludge settles. Clarified water, located above the level of the slurry, goes to a subsequent stage of additional purification. There, waters consequently go through a mechanical filter and selective ion exchange.

![Technological scheme of LWTP 3](image)

**Figure 4. Technological scheme of LWTP 3.**

### 3.4. Wastewater treatment technology of LWTP 4

Treatment of surface effluents from oil products occurs in three stages. The treatment plant also consists of three chambers. The first degree of purification is sedimentation. After that, wastewater enters the second chamber, in which oil products are separated at coalescing filters. Then water enters the third, additional chamber, where the absorbent filters are installed. The residue from the oil separator then proceeds to the oil storage tank and to the grit dewatering bays. The final step of purification is processed at flotation and filtration plant “FFU-15”.

![Technological scheme of LWTP 4](image)

**Figure 5. Technological scheme of LWTP 4.**
3.5. **Industrial wastewater treatment plant**

This plant accepts wastewaters in 2 streams (contaminated with mechanical impurities and oil). At the beginning, the wastewaters enter the oil and grit trap, where the suspended solids are settled and the oils are separated. The resulting sand is fed to the grit dewatering bays. The oil first enters the bunker-oil collector, and then proceeds to the boiler room for combustion and energy production. Then water enters the flotation unit (flotation residual is sent for recycling) and then goes to the filter. After all the steps, waters enter the clear-water reservoir and proceeds to a public sewer.

4. **Conclusion**

As a result of research, an effective technological solution wastewater treatment system of the tractor plant was developed with four local wastewater treatment plants. The mechanical, physical, and chemical methods were applied for technological solution. Water recirculation of pre-treated wastewater and treated storm water is a part of water supply system for the tractor plant. Total water reuse is calculated about 49.7% of water needs for the plant.

**References**

[1] Lykova O and Gogina E 2008 *Vestnik MGSU* **S1** 188

[2] Alekseev S 2018 *Yakovlev's Readings XIII Int. Sci.-Tech. Conf. Dedicated to the Memory of Acad. S. V. Yakovlev* 19 (in Russian)

[3] Makisha N and Gogina E 2014 *Appl. Mech. Mater.* **587-589** 644

[4] Gunatilake S 2015 *J. Multidiscip. Eng. Sci. Stud.* **1** 12

[5] Azimi A, Azari A, Rezakazemi M and Ansarpour M 2017 *ChemBioEng Rev.* **4** 37

[6] Filatova E G 2016 *J. Water Chem. Technol.* **38** 167

[7] Guo H, You F, Yu S, Li L and Zhao D 2015 *J. Membrane Sci.* **496** 31

[8] Teresa M, Reis A, Rosinda M and Ismael C 2018 *Phys. Sci. Rev.* **3** 20180024