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SOLUTIONS FOR OPTIMIZING PROCESSES OF BIOLOGICAL TREATMENT OF WASTEWATER FROM THE TEXTILE INDUSTRY

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ABSTRACT:

In the present paper, the main concerns regarding the purification processes of wastewater from the textile industry containing nitrogen-type dyes are reviewed, and a method for the biological purification of these waters is developed. After consulting the results of the research in this field of wastewater treatment worldwide, a series of effective methods, described in the first chapter of this paper can be taken as positive examples. Following that, some methods of biological treatment of textile and leather industry wastewater are proposed, such as the inclusion of a biological treatment step using a fixed bed reactor. At the conclusion of this paper, recommendations are made for textile fabric operative industry, which are useful in biological contact processes. Biomass support panels, with limited flexibility and substantial surface expansion, with or without frames, form a variety of biomass support elements (textile fabric or otherwise), which can contain biological purification processes through the biomass panels.

1. PRESENT SITUATION ON INTERNATIONAL LEVEL

Due to the demands of the market and the legislation regarding environmental protection, it is necessary to find modern, ecological solutions regarding the purification of wastewater from the textile industry, and chemical textile finishing in particular (Böhm, 2015).

The main sources of concern at the moment are: high values of Chemical Oxygen Consumption (CCO), Biochemical Oxygen Consumption (BCO), and the presence of color, metal ions, and electrolytes. Worldwide estimates refer to the fact that more than 50% of chemical textile finishing enterprises discharge waste water with a degree of toxicity above the existing norms.
Another cause of the intense pollution of the environment turns out to be air polluting agents from chemical textile finishing. Due to this fact, special emphasis is placed on monitoring the emissions of volatile organic substances from coatings, various heat treatments, operations involving the use of solvents, drying, as well as the release of nitrogen oxides and sulfur dioxide from the boilers of thermal stations.

The presence of residues found in the company's effluent, as well as those released into the atmosphere, is another polluting factor that must be taken into account (Böhm, 2015). The existence of solid residues (residues from packaging, unprocessable fibrous materials, but also sludge from the sewage treatment plant), requires the adoption of a strategy for recirculating them in the environment. In this regard, the specialized literature recalls the efforts of American specialists who, in a period of only 5 years (between 1989 and 1994), managed to increase the degree of recirculation of waste water from 23% to 65% (Robescu, 2008; Böhm, 2015; NTPA - 002/2005, „Instalatorul" Journal).

On the international level, there are concerns regarding the purification processes of wastewater from the textile industry that contain nitrogen-type dyes, and a method for the biological purification of these waters has also been developed.

After consulting the results of the research in this field of wastewater treatment worldwide, the following effective methods can be taken as positive examples: two Chinese inventors, Liu Fengming and Liu Xiangjun propose a biological adsorbent material for the high-efficiency treatment of textile wastewater, which is characterized by the fact that it comprises the following components in the following parts by weight: 30-40 parts of bark powder, 35 -55 parts of straw powder, 19-23 parts of sugarcane, 0.001-0.003 parts of Metarrhizium anisopliae powder, 0.001 to 0.003 parts of Hirsutella thompasonii Fisher, 0.001 - 0.003 parts of verticicladiella powder, 1-4 parts of hydroxyapatite, 14-16 parts sodium acid phosphate, 1-7 parts dispersing agent and 3-9 parts stearamide. By using a natural calcium material as a substrate, the biological material has the advantages of cheap raw material, no pollution, low preparation cost, high economy and high yield, reduces environmental load, can effectively treat dyeing wastewater, and is simple to use (Böhm, 2015; NTPA - 002/2005; „Instalatorul" Journal).

Regarding the offer of mixed options for the treatment of textile wastewater containing dispersed nitrogen dye, a method of

biological treatment of textile wastewater has been devised, which effectively and economically removes the respective dyes from the point of view of the required oxygen. To remove the chromatics and chemical oxygen consumption of the textile wastewater, an additional carbon source is injected into the textile wastewater, where mixed strains are applied. The carbon source is additional glucose.

Also in China, in 2012, a secondary device was invented to purify water resulting from textile dyeing. The secondary water treatment device comprises a dissolution tank, in which a pressurizing pump is connected through a pipe, and which is connected to a regulating tank by the pressurizing pump; the regulating tank is in connection with a filtering machine through a pipe and is connected with a reaction tank through the filtering apparatus; a circulation pump to control the flow of sludge back to the control tank is connected above the reaction tank; a press-filter pump is connected to an outlet at the lower end of the reaction tank; the filter apparatus is a stacked coil filter machine consisting of at least one group of stacked coil type filter units. The secondary sewage treatment device also comprises the press-filter apparatus which is arranged above a transport vehicle or a sludge concentration area and is connected to the press-filter pump through the main pipe. The secondary sewage treatment device has the advantage that the working efficiency is high, the performance is stable, the sludge removal ability is strong, the integrated design is adopted, the machine body is light and durable, the automatic control is realized and the reliability is high. The secondary wastewater treatment device is an environmentally friendly water treatment device that is simple in operation, convenient to use, and has high quality efficiency (Robescu, 2008; Böhm, 2015; „Instalatorul" journal).

2. PROPOSED SOLUTIONS

The average annual production of dyes worldwide is about one million tons; the consumption of textiles at the moment is 30 million tons, with an annual increase of 3%.

In order to correspond from a technological point of view, these dyes must present high chemical and photolytic stability. The efforts of specialists in the field have made a good part of the dyes used at this moment meet these characteristics. As a consequence of the high stability of dyes with textile use, it is also the fact that they are degraded to a small extent under the aerobic conditions present in classic purification installations, which means that, in the absence of tertiary purification treatments, a significant amount of dye to be found in purified water (Ionescu, 2015; Robescu, 2008; Sambeteanu, 2013; Böhm, 2015).

Residual dyes in waste water, even in tiny amounts, of the order of 1 mg/l, can cause the appearance of an abnormal coloration of water courses. The studies carried out in this regard have highlighted the fact that it is much more difficult to accept shades of red water than blue or green, a fact that causes public opinion to be alerted.

Depending on the product to be dyed, the class of dyes used, their structure, the type of technological process chosen, respectively the type of equipment, as well as the choice of dyeing parameters: time, temperature, organic auxiliary products and the addition of chemicals, largely depends on the degree of coloring and impurity of the waste water.

Dyeing processes accelerate pollution both through the presence of dyes used and through the existence of color, which itself has characteristics that affect the environment. The large quantity and diversity of dyes used led to the need to evaluate the impact they have on the environment and especially on water pollution. As a result of the low degree of fixation, relatively high amounts of dyes are found in the waste water from textile companies and, from here, in the case of improper purification, in water courses.

Due to the effect of coloring the waters, easily detectable in the case of the presence of dyes, the aesthetic value of running waters and lakes is greatly diminished. This is also the reason why, in the eyes of public opinion, the removal of color from wastewater is more important than the removal of colorless insoluble organic substances, although the latter have the largest contribution to the chemical oxygen consumption value of a given body of water.

The need to evaluate the impact of dyes on the environment is given by the behavior of dyes in natural and biological purification processes and, last but not least, by their effect on aquatic organisms. Since estimates show that only from the total textile dyes for leather products, dye losses represent 11%, the evaluation of the impact of dyes on the environment is mandatory.

In terms of microbial biological treatment, I recommend using a biological treatment mold that is capable of shortening the growth time to reach the steady state from the beginning of the operation of an embedded device and has excellent performance of removing organic materials from water that to be treated, and to provide a biological treatment process using biological treatment as a microbial carrier.

The biological treatment of wastewater from the textile and leather industry comprises an anaerobic pre-treatment stage, an optional stage, with an aerobic or anaerobic activation stage and an aerobic post-treatment stage, which requires the addition of ozone and, optionally, hydrogen peroxide, for treated water and its recycling, which contains dye as process water. The biological treatment of wastewater containing dyes from the textile and leather industry includes:

(a) subjecting the waste water to an anaerobic pretreatment at a negative redox potential for a minimum retention time depending on the nature of the paint;
(b) subjecting the wastewater to facultative anaerobic or aerobic activation, having a 5-day biochemical oxygen consumption (CBO5) of at least 1 kg/m3 per day and a positive redox potential of 0-180 mV to produce activated sludge;
(c) separating the sludge from the sedimentation part and recycling it into several parts (a) and (b) and removing the rest after dewatering;
(d) adding nutrients to the water in step (a) and/or step (b);
(e) subjecting the water of step (c) to aerobic post-treatment;
(f) adding ozone, and possibly oxygen, to the treated water and recycling a major amount of it as process water.

A bioremediation process and equipment for dye-containing wastewater from the textile and leather industries includes

passing the sewage through the anaerobic initial stage with a negative redox potential, sitting in the scene for the shortest time, passing it through both the anaerobic activation stage and through the aerobic activation stage, where the activated sludge is cultivated in volume units greater than 1.0 Kg CBO5 and 0-180 MV of positive redox potential, precipitation, returning part of the activated sludge back to the initial stage, another part of the sludge active back to the activation stage, and finally thickening and then discharging the rest. Nutrients are added in the initial and/or activation phase. Such a process would be suitable for the treatment of wastewater containing nitrogen dye and sulfur dye (Ionescu, 2015; Robescu, 2008; Sambeteanu, 2013; Böhm, 2015; Directiva 86/278/EEC; State standards; U.S. Environmental Protection Agency, 2013-2014).

Another proposed solution would be a regenerative treatment system for wastewater from the textile industry, which includes:

- a grid;
- a regulation tank;
- a sedimentation tank;
- a biochemical tank;
- a water decanter;
- an aerator;
- a sludge concentration tank, in which the grid is arranged at a waste water inlet and used for the separation of various particles;
- the regulating tank is arranged downstream of the grid and in connection with an alkaline liquid pipe for waste;
- the settling tank is connected to the regulating tank by means of a lifting pump.

The biochemical tank is located downstream of the settling tank; the decanter and the aeration basin are arranged downstream of the biochemical tank; the sludge concentration tank is connected to the sedimentation tank and the regulating tank through sludge pumps; the discharge of water from the aeration basin is done through a waste water discharge pipe.

In the sewage and textile wastewater treatment system, the canal water is sequentially subjected to the adjustment of the pH value in the regulating tank, to the sedimentation of the suspended sludge in the settling tank, the oxygenation of the organic matter in the biochemical tank, coagulation, by adding of a coagulant, and decolorization, by adding a decolorizer to the aeration basin, finally ensuring the wastewater purification effect.

The creation of a device for channeling wastewater from the textile industry and reprocessing it through a conventional secondary treatment would lead to the following advantages (Ionescu, 2015; Robescu, 2008; Sambeteanu, 2013; Böhm, 2015):

- organic matter can be degraded further, in phases;
- each phase obtained by membrane separation results in better water quality;
- the concentration phase satisfies the current emission standards, thus resulting in the advanced treatment performance of textile wastewater;
- increasing the water recovery rate and reducing total pollutant emissions.

For the wastewater from the Romanian textile industry, I propose the inclusion of a biological purification step, with the help of a fixed bed reactor, shown in Figure 1.

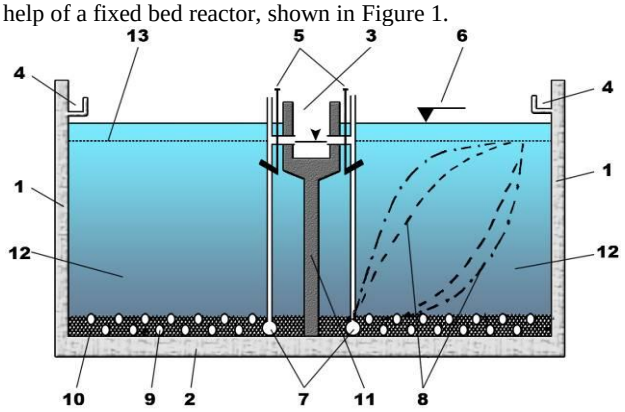


Figure 1. Fixed bed reactor for the biological treatment of wastewater: 1 – reactor side walls; 2 – support – reactor chamber base; 3 – collector channel; 4 – collecting troughs; 5 – butterfly valve; 6 – water mirror; 7 - collection pipes; 8 – flow profiles; 9 – aeration line; 10 – granular material layer; 11 – partition wall; 12 – fixed bed; 13 – upper layer

As supporting elements for biomass, I recommend textile fabric media, useful in biological contact processes. Biomass support panels, with limited flexibility and substantial surface expansion, with or without frames, form a variety of biomass support elements (textile fabric or otherwise), which can contain biological purification processes through the biomass panels.

Figure 2 shows a portion of support for biomass, which comprises a flexible elongated mass of fibers (threads), in the form of an open structure, namely bundles of elongated fibers - filaments in a ball (Figure 3) for supporting the biomass which are sufficiently agglomerated in mass in sufficient numbers to attribute to the mass in question at least one of the following properties:

a. a general thickness value of at least 20mm;
b. a ratio of thickness (T) of the element to the width of the weighted threads of at least 3;
c. an average light transmission value of less than 70;
d. the ratio between weight and water absorbed per unit weight of the element in excess of 3.7;
e. biomass attachment weight capacity per unit weight of clean element of at least 0.8.

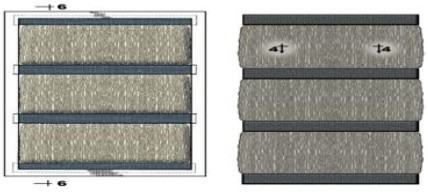


Figure 2. Support plate for biomass



Figure 3 Filaments from the ball

The backing plate comprises corrugated filaments gathered in bundles, which are generally positioned one behind the other in a common direction, positioned parallel in the mass, and which overlap with adjacent bundles in the mass.

The filaments are also 15 times longer and wider than they are thick, and are hydraulically open, meaning water can flow through them from one end to the other when loaded with biomass.



Figure 4. Hypothetical cross-section of the gussets of an element that has approximately flat faces when arranged vertically

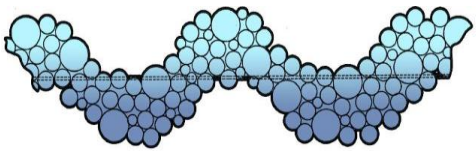


Figure 5. View similar to the one in fig. 4, along a section 4-4 of fig. 2



Figure 6. Vertical cross-section of the panel from fig. 2

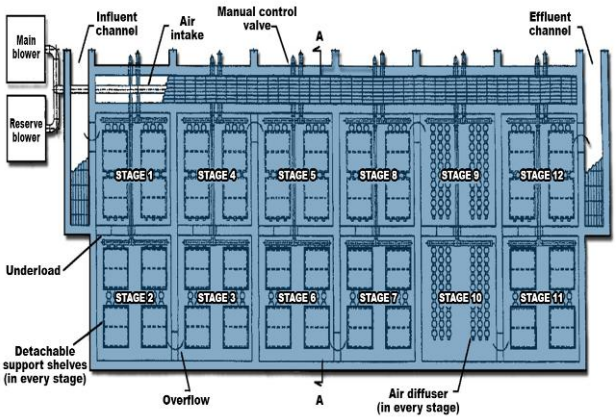


Figure 7. Plan of the treatment plant with the different elements

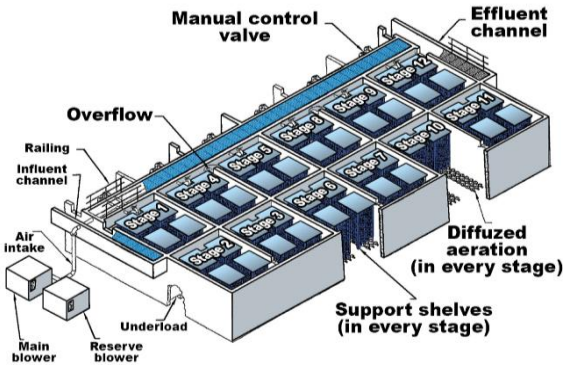


Figure 8. Perspective view of the station in fig. 7

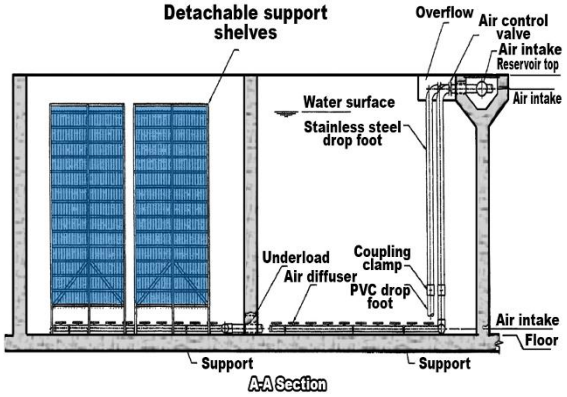


Figure 9. Partial cross-section of area A in fig. 7

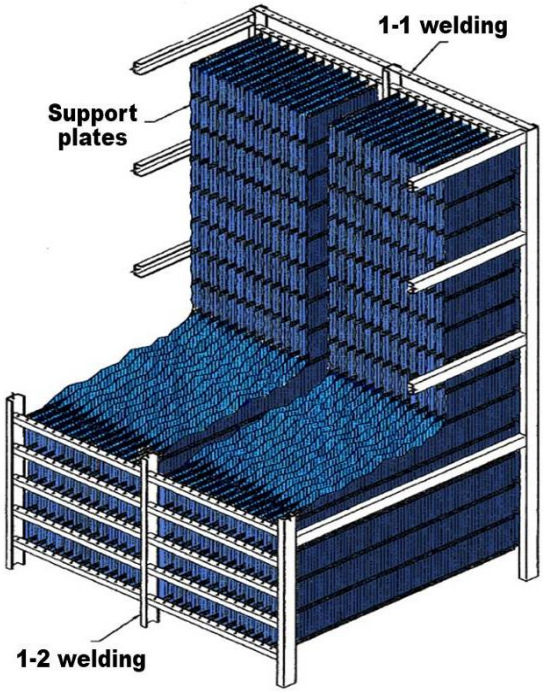


Figure 10. Sectional perspective of a storage panel (support/rack) of biomass retention elements (those bundles of fibers)

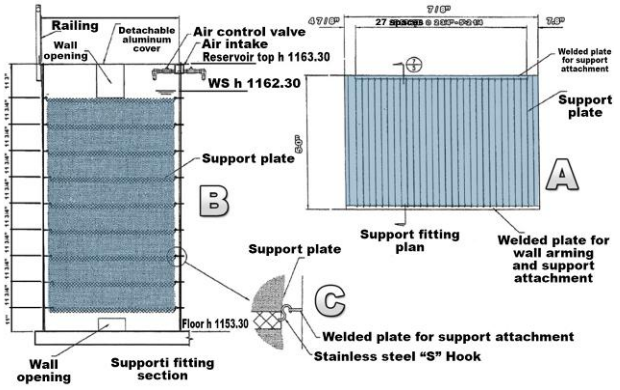


Figure 11. A – plan view of the digestion tank; B – cross section of tank A; C – enlarged portion of a section of the tank

3. CONCLUSIONS

On the international level, there are concerns regarding the purification processes of wastewater from the textile industry that contain nitrogen-type dyes, and a method for the biological purification of these waters has also been developed.

After consulting the results of the research in this field of wastewater treatment worldwide, some effective methods applied worldwide can be given as positive examples, especially in China, where the textile industry has known a great extent.

The present paper lists the most important inventions in the world, which had as a research topic the processes of purifying wastewater from the textile industry.

The conclusion was reached that the realization of a device for sewage treatment of waste water from the textile industry and for its reprocessing by means of a conventional secondary treatment, would lead to numerous advantages.

For the wastewater from the Romanian textile industry, it was proposed to include a biological purification step, with the help of a fixed-bed reactor, whose technological scheme of operation is described in detail.

Future recommendations are made for the textile fabric medium and industry, as presented previously within this paper, which are useful in furthering the technological advancement and improvement of biological contact processes. Biomass support panels, with limited flexibility and substantial surface expansion, with or without frames, form a variety of biomass support elements (textile fabric or otherwise), which can contain biological purification processes through the biomass panels.

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