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Physicochemical treatment of sewage water of a public drain trhough a pump and recirculation filtration system using a filter bag as a filter mean

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Abstract : *Nowadays water reuse is becoming more necessary as a strategy to wane the negative impact of sewage water in the environment.*
The objective of the investigation project was to apply a treatment in the sewage water of a public drain in Huacho (Peru) through a pumping and recirculation filtration system using a filter bag as a filtrating mean to obtain water to reuse. The water of the public drain comes from the natural overflow of the "La Encantada" lake which is about 10 kilometers away from where the sampling was made; these waters are mainly contaminated by a part of the town that lives close to the drain.
The research was realized in sequentially dependent phases for its optimal culmination, which were: Physical chemical characterization and concentration of coliform bacteria from irrigation water; use of mesh sieves Tyler N°60, in order to separate solid waste in suspension present in sewage water; conducting experimental runs with filtration equipment that includes the filter bag to determine the proper porosity of the filter bag and the optimal recycling time; chlorination of treated irrigation water in order to completely inactivate the microbial population present in these waters and as a last phase the physicochemical characterization and concentration of coliform bacteria was realized for its comparison with the quality requirements according to the type or use of water demanded by the authorizes that regulate and control water use.
The turbidity rate was considered as a representative indicator of the efficiency of the removal of solids present in the irrigation water. The removal data obtained for the granulometric variants A (4 microns), B (5 microns) and C (6 microns) were of: 95.37%, 98.95% and 98.05% respectively. These results are high and show that the filtration system is efficient within a recirculation span of 20 minutes. The obtained result is water, that previously chlorinated, can be categorized as water type III suitable for the irrigation of vegetables and animal drinks

Keywords *Sewage water Treatment, filtration, filter bag, reuse of sewage water*

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I. INTRODUCTION

Water is an essential compound for life; it is used in food, in agriculture, industry, etc. And it is the way in which the majority of physicochemical and biological reactions are produced, which is fundamental for life. Knowing the quality and availability of water for its different uses are important factors to the wellbeing and progress of a nation; but it is not solely dependent on the type of soil, weather, drainage system, irrigation techniques and available flows of water, but in a fundamental way in the physicochemical quality of water (Carrera-Villacréset al., 2015).

Around 80% of clean water turns into residual water, its use determines the deterioration of the conditions of life in the rural population (Cisneros et al., 2001). Due to the lack of water waste systems, more than 95% of these waters go directly into the rivers or the oceans without any previous treatment (Mayorga-Llerena, Carrera-Villacrés, 2015).

A tradition of communities without adequate planning, is to pour domestic wáter waste directly into the bodies of surface wáter (Giogioset al., 2005); the use of waste water constitutes a source of contamination by the user whether it is in a direct or indirect manner. The irrigation of arable zones using domestic waste water constitutes a risk for human health due to the prescense of pathogens that involve: virus (enterovirus, adenovirus and rotavirus), bacteria (coli forms, etc.), protozoon or helminths (earthworms) of human origin, these foods must not be consumed raw, they must be naturally dehydrytated before its consumption (Mara, Cairncross, 1990; Fasciolo et al., 2005). Wastewater generate problems to public health, 40% of urban population in Latin America gets infectious diseases associated to water (Velizet al., 2009).

The treatment and recycling of sewage water is an important factor considering that this reduces pressure over availability and quality of water, besides is also minimizes the discharge of untreated wastewater into rivers and oceans (Maggi et al., 2011; Plevichetal.,2012).

Non planned reutilization is normal and natural of the water cycle because great quantities of wastewater that is poured, after its dilution and natural depuration into rivers and other bodies of water, is reused down to other users. However, this situation must make way towards a planned reutilization where wastewater, after being adequately treated, whether it's by artificial wetlands (Romero-Aguilar, 2009; Galindo et al., 2016; Marín-Muñíz, 2017) conventional primary treatment plants, secondary and tertiary (Cruz-Henao, 2015; Yucra, 2016), has the necessary quality, regulated by normative frameworks, for its direct reutilization.

Water treatment systems: It is categorized in: preliminary, secondary and tertiary; while according to the mechanism, the methods are classified as:

- Non destructive or physical that includes: mechanical techniques (roughing, sedimentation), of adsorption (by activated carbon), desorption (stripping), extraction with solvents and membrane filtration (ultra and nano filtration, and
- Destructives that include biological treatment (anaerobic and aerobic) and chemical oxidation. The destructive methods of chemical oxidation are classified in 2 categories: direct and advanced. The first are those that use oxygen as an oxidizing agent and include: incineration, humid oxidation (Wet Air Oxidation, WAO), catalytic humid oxidation (Catalytic Wet Air Oxidation, CWAO), super critic (Supercritical Wet Air Oxidation, SWAO) and anodic oxidation (AO) or electrochemical. The advanced methods imply the generation of radical hydroxyls [OH] likes:O_3, H_2O_2, ultraviolet radiation and the Fenton method (Taco y Mayorga-Llerena, 2013).

Ascendant-descent filtration systems: The biological ascendant filtration systems are types of anaerobic reactors that allow maintaining the wastewater in suspension, it constitutes a continuous treatment process, the use of porous material allows the formation of a fixed-film that assures the retention of solid by adsorption, being the pumice stone an adequate bio-filtration material (Kocadagistanet al., 2005).

The Phosphates in natural water is fundamental it is important to know the concentration to evaluate the risk of eutrophication. This element is usually the limiting factor en ecosystems for vegetable growth, and a big increase in its concentration can cause eutrophication in the water. With this, Phosphates are directly related with the eutrophication of rivers, but specially of lakes and reservoirs (Aznar-Jiménez, 2000). The increase of phosphorus in the environment is due to intensive agriculture and livestock production, besides the sludge coming from the wastewater. High concentration of phosphorus indicates water contamination by effluent urban industries (Villacrés, 2011).

The sanitary quality of irrigation water is determined by the number of fecal coliforms as an indicator of the level of bacteria that generate enteric diseases in humans. The water quality for agricultural use is categorized in 3 types as observed in Table 1.

Table 1. Guidelines of the Engelberg WHO report about microbiology quality of wastewater for its use in agriculture (1)

Class	Conditions of use	Fecal Coliforms (2) (geometric mean/100 ml)
A	Irrigation of crops that are consumed raw, sports fields, or public parks.	<1000
B	Irrigation of cereal crops, industries, fodder, meadows (3) and trees (4)	No norm is recommended
C	Localized crop irrigation of category B when neither workers nor public are exposed.	Not Applicable

In specific cases; epidemiological, socio cultural as well as environmental factors of each place should be taken into account and have guidelines modified accordingly.
During the irrigation period.

it is convenient to establish a stricter directive (< 200 fecal coliforms per 100 ml.) for public meadows, like that of hotels which the public can come into direct contact with.
in the case of fruit trees, irrigation must cease 2 weeks prior to harvesting its fruits and these should not be picked up the ground. it is not convenient to water by sprinklers.

II. METHODOLOGY

The representative sample of the mentioned population is composed by a quantity of 100 liters of waste water to make the necessary analysis and the experimental trials with the filtration equipment in the laboratory.
In order to develop the present investigation task it was required the following materials and equipments.

Materials: Sample of water from public drain (100 liters); Distilled water, Tyler sieves N°60; Decantation pear; Thermometers of 0-110 ºC; Pyrex beakers of 0.5-0.25 L; Kitasato flask.

Equipment: Filtration equipment which includes the filter bag and a centrifugal pump for the recirculation of the sample to be treated; Filter bags (Filter channel) with granulometry of 4, 5 and 6 microns, denominates filter bags A, B and C respectively; Chronometer, Digital weight scale, multi-parameter ph meter Fisher Scientific XL-200; Hanna Turbid meter; Vacuum pump.

In the present investigation for the treatment of wastewater, water was filtered out of the public drain through a filter bag arranged in a double container with a forced entrance passing to the filter bag due to the impulse of a centrifugal pump, connected to the filtration system with recirculation of wastewater to be purified. This system that operates in a discontinued matter, is basically made up of an agitator tank made up of steel, which is the receptor of the wastewater, of 50 L provided by an agitator driven by a reduction motor that regulates the agitation to 90 RPM, the suspension in a quantity of 40 L is agitated and loaded continually to a centrifugal pump of 2 HP, which pumps the suspension towards the canvas bag filter continually (Figure 1). The solid waste are retained in the filters interior, as the water recirculates through the filter the solid residue is retained and at the same time water passage through the filter becomes more difficult which is evidenced by the increase of pressure in the system, that is measured with the pressure gauge installed in the pipeline. In our investigation the filter channel is of a granulometric size of 4, 5 and 6 microns (Filter Bag A, B and C respectively). The advantages of the system according to the manufacturer is the high filter efficiency, low operation costs, fast replacement of the channel, high particles retention capacity, high flow rates at low loss of charge, different types of filtration within the same recipient, unbeatable for filtration systems by Bach (Legua-Cárdenas et al., 2016).
The current work of investigation is composed of five sequential independent phases for its optimal finalization, these are the following:

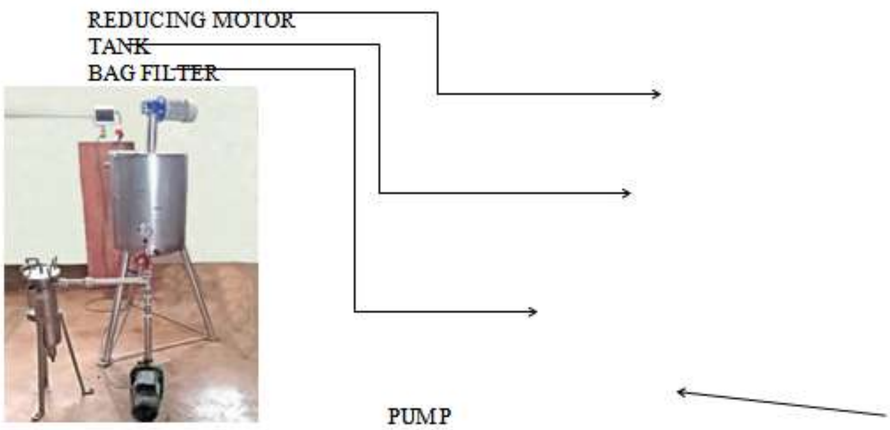

Figure 1 Pumping and Recirculation filtration system used in our investigation using a filter bad as a filter cannel.

First Phase: Coliform and physicochemical Characterization of waste water that runs through public drains used as water coming from “La Encantada” lake, which will allow to determined the selection and correlation of the variables that control the treatment that included the filtration with filter bags.
Second Phase: Using Tyler mesh sieves N°60, to separate the solid residue in suspension present in the wastewater of the public drain, this treatment will facilitate the filter bag filtration.
Third Phase: Realization of experimental runs with the filtration equipment to determine the adequate porosity of the filter bag and the recycled time having as references the water quality in term of TDS, turbidity, conductivity, etc.
Fourth Phase: Tests of chlorination of treated irrigated water with the purpose of totally inactivating the microbial population present in the water of public drains, so that these waters reach the adequate chlorine concentration in ppm.
Fifth Phase: Physicochemical and Coliform concentration characterization to compare it with the quality requirements demanded by water authorities in order to reuse it.

Statistical Analysis

The statistic test ratifies the efficient achieved result with the filtration system with recirculation used, for statistical verification the unidirectional MINITAB ANOVA was applied and the “F” distribution for 5%, where a statistical significance was found.

III. RESULTS AND DISCUSSION

In our investigation the water waste from pubic drains were analyzed, which has a parallel line to the university campus of the Universidad Nacional José Faustino Sánchez Carrión, in the city of Huacho. We would like to reuse this waterwaste (with prior validation) in our university (Sánchez, Aponte, 2013).

About 15% of rivers in Latin America show concentration of fecal coliforms with values equal or higher to 10000 UFC/100ml in water that is used for irrigation (Velizet al., 2009).

Physic-chemically and microbiologically it characterized at a basic level but relevant to the investigative work realized.

It was hypothesized that if from a treatment including a filter bag to the irrigated waters from public drains is possible to use for different services.

The water from the public drain underwent tests of filtration with recirculation and agitation in a tank before the water entered the centrifugal pumps, three different filter bags of different porosity were used, and those results are illustrated in table 3 and table 4, figure 2 was made starting from that information, which tells us the percentages of removal of the turbidity index according to the bag filter used.

The initial and useful results of the microbial analysis made for the investigation is presented in table 2.

Table 2. Results of the analysis of coliform numeration

Microbiological parameter NMP/1000 ml	n	
Fecal Coliform Numeration	1,8	1,8
Total Coliform Numeration	1,8	

Table 3. Experimental tests of Filtration with recirculation with the filtration channels: A, B and C.

Physicochemical Parameter	Filter Channel A		Filter Channel B		Filter Channel C	
	Before Treatment	After Treatmen t	Before treatment	After Treatme nt	Before treatment	After Treatment
Conductivity (mS/cm)	1.94	1.60	1.94	1.46	1.94	1.47
TDS (ppt)	1.13	0.97	1.13	0.87	1.13	0.87
Resistivity (KOhm)	5.39	6.25	5.39	6.85	5.39	6.82
Salinity (ppt)	0.78	0.68	0.78	0.62	0.78	0.62

In the tests, using the filter cannel with recirculation with the filter channels A, B and C, the following experimental results were obtained, which are shown in table 3. The physicochemical paratemers that were evaluated were the following: Conductivity, Resistivity, Salinity and others. In the tests, using the filter channels with recirculation with the filter channels A, B and C, the following results were obtained which are shown in Table 3.

The results that are illustrated in Table 3 reflect separation of dissolved solids and natural colloidal solids, this last one is directly related with the turbidity that the water tests show, so it is convenient to appreciate the turbidity decline speed in front of time of filtration with

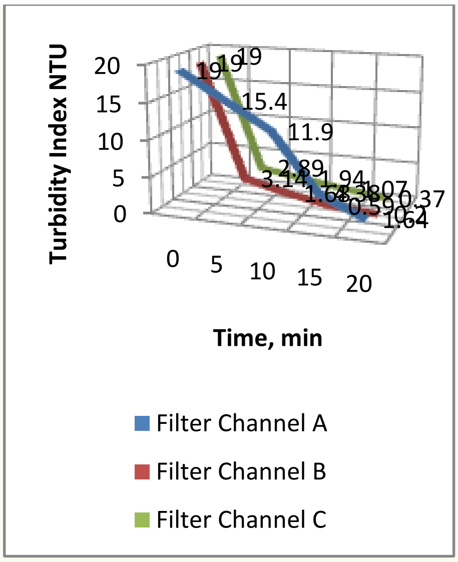

Figure 2: Variation of the Turbidity Index NTU in dependence of the used filter channel and at the time of filtration

recirculation experimented with the three filter bag channels, finding the following results that are presented in Figure 2.

Besides the objective of improving the physicochemical and microbiological Quality of irrigation water using the bag filtration with recirculation technique with the help of a centrifugal pump, there are also other relations with the equipment operation variables that require experimental tests to achieve optimization in the management of the equipment that is available. One of these parameters is the porosity of the duffle bag for this purpose three duffle filter bags each of different porosity were available.

Uzalet al. (2010) indicates that a member based treatment strategy was developed for the possible recycling of rinsed wastewater dyed with indigo for the process. Three different nano-filters (NF) were used (NF 270 and NF 90, manufactured by Dow Film Technology, USA and NF 99, manufactured by Alfa Laval, Denmark) and two different of inverse osmosis (RO) (HR 98 PP and CA 995 PE, manufactured by Alfa Laval, Denmark) with wastewater recollected since the first post-rinse tank of the indigo dyeing process of a denim manufacturing plant. Deadend microfiltration was used with a 5 micron filter to eliminate the thick particles and minimize the fouling of new membranes of NF (nanofilters) and RO (inverse osmosis).

In our research high removal rates percentages were achieved, as seen in Table 4, that go from 91.37% to 98.95% comparable to the results that were reached in a prior research (Legua-Cárdenas et al., 2016).

Table 4. Correlation of Variation of the Removal Percentage of the turbidity index in respect to the Filter Bag type

Type of Filter Channel	Turbidity Index before treatment (NTU)	Turbidity Index after treatment (NTU)	Percentage of removed turbidity %
Filter bag A	19	1.64	91.37
Filter Bag B	19	0.2	98.95
Filter Bag C	19	0.37	98.05

In this research, a physicochemical treatment of wastewaterwith high content of Barium (BA) was carried out, using a filtration equipment with recircullation using a filter bag, reaching percentages of removal of salts of the order of 100, 40, 10 and 5% for the salts of $BaSO_4$, $SrSO_4$, CaSO4 and $MgSO_4$ respectively, obtaining in this case, like the present research work, moderately diluted solutions.

To apply the MINITAB software, data from table 4 was used in order to give reliability to the hypothesis raised from the most relevant results of the applied treatment. Statistically, a 5% significance was found according to the statistical evaluation applying the unidirectional MINITAB ANOVA and the "F" distribution for the 5% significance level, for the turbidity index data the following values were found for "p" and "F", for the correlation of the input and output variables, C1 = Turbidity index (before treatment) vs C2 = Turbidity index (after treatment).

$P = 0.00 < 0.05$; $F = 1615.95 > 5.12$

Run of the MINITAB program:

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        One-way ANOVA: C1; C2

Source  DF      SS      MS       F      P
Factor   1  500.324  500.324  1615.95  0.000
Error    4    1.238    0.310
Total    5  501.562
S = 0.5564   R-Sq = 99.75%   R-Sq(adj) = 99.69%

        Individual 95% CIs For Mean Based on Pooled StDev

Level  N    Mean  StDev   +---------+---------+---------+---------
C1     3  19.000  0.000                           (-*)
C2     3   0.737  0.787   (*-)
                          +---------+---------+---------+---------
                        0.0       6.0      12.0      18.0

Pooled StDev = 0.556
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The experimental work was oriented towards the improvement of the quality of the irrigation water, which presented contents of dissolved solids, colloidal and in suspension that give the water a moderately cloudy appearance that is verified by its DBO5 content as shown in Table 5.

Table 5: Biochemical Oxygen Demand and Chemical Oxygen Demand of the Treated Water.

Tests	Method	Limit of Quantification	Units	Results
Biochemical Demand of Oxygen (DBO_5)	SM 5210 B. Biochemical Oxygen Demand (BOD). 5 - day BOD Test.	2.00[(a)]	mg/L	< 2.00
Chemical Demand of Oxygen (DQO)	SM 5220 D. Chemical Oxygen Demand (COD). Closed Reflux, Colorimetric Method.	10.0	O_2 mg/L	17.52

a. Expressed as the detection limit of the method.

IV. CONCLUSIONS

The residual water from the "La Encantada" lagoon was physicochemically characterized for the research work carried out. Having found moderately contaminated residual irrigation water with a low concentration of dissolved and suspended solids.

The solids in suspension were separated with the aid of a Tyler 100 and 150 mesh sieve, making the water ready for the filtration treatment with recirculation of the agitated irrigated water with a speed reducing motor.

With the results of Figure 2 where the rate of descent of the turbidity index was correlated for the three filter media of different porosity, the recirculation time that resulted in 20 minutes was determined for the operating conditions of the equipment, in other words the flow, type of filter medium, no use of coagulants or flocculants, power of the centrifugal pump, on the other hand also the initial physicochemical conditions of the sample of irrigation water.

The porosity of the bag filter was selected from the results of table 5, where the filtering medium B registers a slightly better efficiency than the other filtering media, under the same conditions of operation of the filtration with recirculation of the irrigation water.

Taking into account the turbidity index is the best indicator of the removal efficiency of solids present in irrigated water. The percentages of removal are the following values: 95.37, 98.95 and 98.05 that are high and demonstrate the efficiency of the filtration system with recirculation used.

The product obtained is water that previously chlorinated could be categorized as type III for use as irrigation water.

The statistical test confirms the efficient result achieved with the filtration system with recirculation used, for the statistical verification the unidirectional MINITAB ANOVA and the "F" distribution were applied, where a statistical significance was observed.

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