

Análisis del pretratamiento de aguas residuales de lavanderías mediante filtros orgánicos de coco

Analysis of the pretreatment of wastewater from laundries through organic coconut filters

Recibido: 26 de marzo de 2024 | Revisado: 01 de abril de 2025 | Aceptado: 10 de junio de 2025

Cesar Augusto Paccha Rufasto¹

Duber Enrique Soto Vasquez²

1,2 Facultad de Ingeniería Civil – Universidad Nacional Federico Villarreal. Lima, Perú

1 Correo: cpacchar@gmail.com
<https://orcid.org/0000-0003-2085-3046>

2 Correo: dsoto@unfv.edu.pe
<https://orcid.org/0000-0002-4505-2053>

<https://doi.org/10.62428/rcvp2025411742>

Abstract

The growth of cities is related to the increase in urban wastewater, in the study organic coconut fiber filters were designed for the pre-treatment of wastewater from laundries, physical activation of carbon was carried out, and combinations of physical and chemical activation, a removal efficiency was obtained in different efficiency percentages, filter 13 (Physical Activation) and filter 6 (Chemical Activation (ZnCl_2) - 20% - 5 Hours), with a removal of 63.79% and 63.22% respectively for oils and greases, filter 1 (Chemical Activation (H_3PO_4) - 20% - 3 Hours) and filter 9 (Chemical Activation (KOH) - 20% - 5 Hours), with a removal of 33.21% and 32.69% respectively of biochemical oxygen demand, filter 10 (Chemical Activation (KOH) - 20% - 3 Hours) and filter 9 (Chemical Activation (KOH) - 20% - 5 Hours), with a removal of 56.56% and 52.66% respectively of chemical oxygen demand, filter 1 (Chemical Activation (H_3PO_4) - 20% - 3 Hours) and filter 13 (Physical Activation), with a removal of 86.82% and 86.47% respectively of total suspended solids, filter 8 (Chemical activation (ZnCl_2) - 40% - 5 hours) - 20% - 3 Hours) and filter 4 (Chemical Activation (H_3PO_4) - 40% - 5 hours), with a removal of 89.71% and 76.46% respectively of ammonia.

Keywords: Organic filters, removal efficiency, chemical oxygen demand, biochemical oxygen demand, pre-treatment of wastewater.

Resumen

El crecimiento de las ciudades está relacionado con el aumento de las aguas residuales urbanas. En el estudio se diseñaron filtros de fibra de coco orgánica para el pretratamiento de aguas residuales de lavanderías. Se realizó la activación física del carbón y combinaciones de activación física y química, obteniéndose una eficiencia de remoción en diferentes porcentajes. El filtro 13 (Activación Física) y el filtro 6 (Activación Química (ZnCl_2) – 20% – 5 horas), con una remoción de 63,79% y 63,22% respectivamente para aceites y grasas; el filtro 1 (Activación Química (H_3PO_4) – 20% – 3 horas) y el filtro 9 (Activación Química (KOH) – 20% – 5 horas), con una remoción de 33,21% y 32,69% respectivamente de demanda bioquímica de oxígeno; el filtro 10 (Activación Química (KOH) – 20% – 3 horas) y el filtro 9 (Activación Química (KOH) – 20% – 5 horas), con una remoción de 56,56% y 52,66% respectivamente de demanda química de oxígeno; el filtro 1 (Activación química (H_3PO_4) – 20% – 3 horas) y el filtro 13 (Activación Física), con una remoción de 86,82% y 86,47% respectivamente de sólidos suspendidos totales; y el filtro 8 (Activación Química (ZnCl_2) – 40% – 5 horas) y el filtro 4 (Activación Química (H_3PO_4) – 40% – 5 horas), con una remoción de 89,71% y 76,46% respectivamente de amoníaco.

Palabras clave: Filtros orgánicos, eficiencia de remoción, demanda química de oxígeno, demanda bioquímica de oxígeno, pre-tratamiento de aguas residuales.



Este artículo es de acceso abierto distribuido bajo los términos y condiciones de la licencia Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International

Introduction

Global change seriously affects the structure and functioning of both urban and rural ecosystems, knowledge of aquatic ecosystems is essential, recent studies show that indicators of the serious effects caused by global change such as pollution can cause invasion by exotic species, loss of ecosystem services (Alonso et al., 2022). In countries where demography continues to grow, pollution treatment is very important. In Peru, the treatment of urban wastewater is an unresolved problem, which is why demands for new technologies have arisen, which help to conserve and protect bodies of water (Pérez, Cortés and Jauregui, 2022), on the other hand, the controversy about the Wastewater treatment, for its subsequent disposal to water sources, in recent years has taken on greater importance, due to the Estándares de Calidad Ambiental (ECAs) and Límites Máximos Permisibles (LMPs) carried out by the Autoridad Nacional del Agua [ANA]. In the world, different methodologies are used taking into account criteria at the discretion of the professional, and the application of qualitative and quantitative parameters, particularly for water resources, the proposed methodologies and tools that allow for an in-depth analysis are limited (Corregidor et al., 2023).

An adequate wastewater treatment system would offer a quality service framed in efficiency and functionality, guaranteeing compliance with the parameters of the internal regulations established according to United Nations Educational, Scientific and Cultural Organization (UNESCO, 2019), removing garbage, grease, oil, sludge, from treated wastewater and solid waste must be in an environmentally sound manner to reduce contamination and risk of disease. Worldwide, more than 80% of all municipal and industrial wastewater enters the environment without proper treatment. Treated wastewater is released into surface water bodies, while sludge and other solid waste is sent to landfills. The need for innovative technology, fit-for-purpose and cost-effective solutions is a necessity for the safe collection, transportation, treatment and disposal of waste.

In Peru, the Centro Nacional de Planeamiento Estratégico (CEPLAN, 2020) the proper use of excreta disposal services would prevent the spread of intestinal parasites (worms), schistosomiasis and trachoma, and with it the reduction of gastrointestinal diseases such as diarrhea, which impact people's quality of life and also contribute to environmental pollution. In 2018, at the national level, 82.6% of the population used sanitation services, with access in rural areas close to 51.1% of the population and in urban areas approximately 91%.

Current laundries in Peru are informal and consume large amounts of water during the washing and rinsing processes. These laundries can be classified within the industry according to various characteristics, which vary depending on the amount of clothing to be cleaned, its origin, and the washing technology used. Generally, the products used in this sector include detergents, bleaches, stain removers, enzymes (which accelerate the breakdown of proteins such as egg or blood, among others), fabric softeners, and other resources (Uturi, 2019).

According to Yamaguchi et al. (2020), they indicated that the use of moringa as an additional coagulant (usually alum) has a high efficacy in water purification methods, increases effectiveness by 20%, decreases the use of chemical coagulants by 60% and minimizes contamination of the final treated water.

For Bastidas et al. (2010), an experimental activation unit was set up to obtain activated carbons from bituminous coal, coconut endocarp, and palm endocarp. The bituminous coal and biomass materials used were sourced from the Department of Cesar (Colombia) and activated in a controlled atmosphere furnace. The specific surface area values of the activated samples were determined from N₂ isotherms. The activated carbonaceous materials were used for the adsorption of phenol in aqueous solution at different concentrations. Activated carbon obtained from coconut endocarp achieved the highest BET surface area of 1200 m²/g and adsorbed the highest amount of phenol. However, experiments with other materials demonstrated that basic groups contained in the adsorbent material and its microporosity are determining factors for phenol adsorption.

For Cueva and Lazarte (2021), the removal of arsenic through the use of a biofilter with activated carbon from coconut shell in the water of the Tablachaca River was efficient. For such arsenic removal, they designed, built and evaluated the treatment system, consisting of the following units: The rapid mixing tank that has a storage capacity of 7.8 liters, where the water is agitated at 401, 361 and 291 rpm for doses of 35, 40 and 50 mg/L respectively, in a period of 30 seconds; The original rectangular settler had a capacity of 43 liters and in the end,

the filter had a filtration rate of 120 m/d and a depth of 1 m, composed of gravel and sand. The findings showed that the initial concentration of arsenic was 0.0376 mg/L, after treatment with different doses figures lower than 0.008 mgAs/L were reached, therefore, it was concluded that using coconut shell activated carbon as a bioadsorbent, the treated water meets the requirements established in the regulation Decreto Supremo N.º 031-2010-SA.

Baharum et al. (2020), evaluated the adsorption (when atoms, ions, or molecules of a substance adhere to the surface of the material) of diazinon from aqueous solutions onto coconut shell modified biochar. Dosing amount and initial pH are the main parameters that were studied to obtain the maximum adsorption capacity of the probe molecules. Carbonized coconut shell biochar (BC1), activated coconut shell biochar (BC2), chemically modified phosphoric acid (BC3), and sodium hydroxide coconut shell biochar (BC4) were prepared and tested as variables in the adsorption experiment. The characteristic of biochar through SEM, EDX, and BET analysis revealed the large porous surface morphology and slight changes in composition with high surface area (405.97 - 508.07 m²/g) following the sequence of BC3>BC2>BC4. A diazinon removal rate of as high as 98.96% was achieved at pH 7 with BC3 as the adsorbent dosage at 5.0 g/L. Therefore, the results obtained showed that BC2 and BC3 are highly efficient adsorbents and both exhibit great potential for diazinon removal from aqueous solutions.

Ighalo and Adeniyi (2020), explained that plant barks are among the most widely used low-cost biomass materials in the study of contaminant removal from aqueous media. This paper extensively reviews the experimental findings presented in the open literature with special emphasis on the last 15 years. This study classified plant bark adsorbents into 5 broad groups: unmodified biosorbent, pre-modified biosorbent, chemically modified biosorbent, physically modified biosorbent, and bio-based activated carbon. Eucalyptus, pine, acacia, and mango were observed to be the most explored species in tree bark adsorption studies. The review clarified the excellent adsorption capacities of plant bark-based adsorbents and biosorbents for the uptake of heavy metals, dyes, pesticides, and other contaminants. It was observed that plant bark has a high potential for reuse, which underlies its usefulness for industrial applications.

Johari et al. (2015) explained that Coconut shell (CH), which consists of coconut pith (CP) and coconut fiber (CF), is abundant and cheap, and has the potential to be used as an adsorbent for the removal of elemental mercury (HgO). The CP and CF surfaces were modified by mercerizing and bleaching methods and characterized by scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), and moisture and ash analysis. Elemental mercury adsorption measurements were carried out under the following conditions: initial HgO concentration 200 ± 20 mg/m³; bed temperature, 50 ± 1 °C; N₂ flow rate, 0.05 L/min; adsorbent mass, 50 mg; and adsorbent particle size between 75 and 100 mm. The surface morphology and surface functional groups of the adsorbents changed significantly after the treatments, resulting in different HgO adsorption performances. The breakthrough experimental data for all adsorbents produced a good fit to the pseudo-second-order kinetic model.

Given the problematic reality that rural and urban areas are going through in the different regions of Peru, with more emphasis on companies such as laundries in Peru, it has been prudent to present the following research work that seeks to design a filter for the treatment of wastewater product of washing clothes in laundries using unconventional adsorbent materials, in order to achieve an eco-sustainable system.

Salas, Alberto and Guerrero (2007), integrated several studies, some investment costs of treatment systems, which are presented in (Table 1).

Table 1
Direct investment costs for wastewater treatment systems (as of 2002)

Process	(S/ Hab)		(\$ / hab)	
	Mínimum	Máximum	Mínimum	Máximum
Preliminary	4.4	17.6	2	8
Primary	44	66	20	30
lagoons	22	66	10	30
trickling filters	66	132	30	60
Muds activated	88	264	40	120
UASB	44	88	20	40

Biochar

As is known, biochar is a carbonaceous material produced by the thermochemical decomposition of biomass in an environment with little or no oxygen. Biomass can be any organic residue such as agricultural or forestry, municipal sewage sludge or organics (Colantoni et al., 2016). Biochar has received special attention in recent years due to its high carbon content, high cation exchange capacity, large specific area, and structural stability (Rizwan et al., 2016). Pyrolysis is one of the methods used for decomposition thermochemistry (Mohan, et al., 2014). Among the various uses of biochar are water treatment (Agrafioti et al., 2013), and soil, fertility and crop productivity improvement (Ahmad et al., 2021). These and other properties make biochar an important compound to solve environmental pollution and soil degradation. Pyrolysis, which is carried out in an anoxic or hypoxic medium, is the preferred heat treatment for the production of biochar. Pyrolysis is carried out between temperatures of 300 to 850 °C, for a time between 1 to 3 hours. This is a simple, reliable, cost-effective process applicable to both small and medium scale (Xiang et al., 2020).

The possibility of developing materials with adequate adsorption capacities from natural sources arises, alternative materials considered "unconventional" are explored, which would reduce or eliminate contaminants of a metallic or organic nature, contained in wastewater. Unconventional adsorbents (green or bioadsorbents) arise from the use of waste materials that come from the food and agricultural industry; these are fruit debris, vegetable residues and plants. The origin or source of obtaining the unconventional adsorbents used in the methods of treating contaminated wastewater.

1. live and non-living biomass (microorganisms)
2. agro-industrial waste materials
3. waste materials from the food industry.

The application of natural fabrics as non-conventional materials for the adsorption and removal of metals and dyes in wastewater treatment is in its beginnings in universities and research institutions in the country. Despite the fact that there are several reports that mention the adsorptive capacity of the tissues of plant species such as seeds, trunks, leaves, stems, etc., research is required to explore the applications of the process, and technological design according to the problem that need to attack (Valladares et al., 2016).

Due to the fact that today there is a lack of having a low-cost wastewater treatment, and accessible to many communities and industrial businesses, it seeks to achieve a sustainable system of domestic wastewater, through the use of coconut shell as adsorbent unconventional in the treatment of wastewater from laundries, to reduce costs and that the treatment of wastewater is adequate for its final disposal and likewise is within the reach of laundry businesses before they discharge into the collection network drainage, since many times they discharge crude oil into the sewerage network without any prior treatment (Superintendencia Nacional de Servicios y Saneamiento - SUNASS, 2016), unlike the background found in this research work, it has been possible to notice that they use different organic products for the treatment of wastewater, for the adsorption of heavy metals and organic compounds, but more research is needed regarding unconventional adsorbents based on organic products, the present study took into account the wastewater from a laundry in San Juan de Lurigancho.

Physical and chemical activation of biochar

The objective of the activation process is to increase the pore volume, increase the pore diameter and increase the porosity developed in carbonization (Yaashikaa et al., 2020). During this process, oxygenated functional groups are incorporated into the carbon structure, generating a more "active" carbon for specific applications. The activation process can be carried out by three different methods: physical activation, chemical activation and physicochemical activation (a combination of physical and chemical activations) (Ioannidou and Zabaniotou, 2007).

Physical activation

The physical activation that is carried out in obtaining physically activated carbon, went through a burning process and then through a carbon washing process (Sujiono et al., 2022), to obtain a carbon that is clean of

impurities and dust. of the same carbon that forms a dye in the water, the washing process to obtain the material is a process in stages of elimination of turbidity from the filtrate of the cleaning of the carbon in the two granulometries as fine aggregate (AF) and coarse aggregate (AG)., this process was carried out by means of syringes with water to rinse the carbon. For this, filter paper was used and containers with an average capacity of one liter, the filtrates have been constantly.

This form of activation involves carbonization of a carbonaceous material in the range of 400-850 °C and sometimes up to 1000 °C, followed by activation of the resulting material at temperatures ranging from 600 °C to 900 °C in the presence of gases such as CO₂, steam, air or a mixture of gases (Ioannidou and Zabaniotou, 2007). Pistachio shells (Lua and Yang, 2004), orange peel (Peña, Giraldo and Moreno., 2012), peanut shell (Wu et al., 2018), have been some of the raw materials studied by this method.

Chemical Activation

We worked with three chemical elements such as phosphoric acid (H₃PO₄), potassium hydroxide (KOH) and zinc chloride (ZnCl₂) each bottle contained 250 ml, the dosage of the chemical element to be used for activation is uniform in the three components, in an average of 30 ml that was placed for each container of charcoal weighing 45g for each one of it, in the activation processes it went through three phases, first application of the chemical in the charcoal, second passed the baking of the charcoal with the mixing of the chemical and as a third phase is the cleaning of the coal (Sujiono et al., 2022) as it was done with the physical activation process, in the stage of burning the coal together with the chemical in the oven the temperature average was 400 °C, the proposed time that was considered in the experimental study for the activation of the carbon in the oven was 3 hours and 5 hours, likewise it was proposed by criteria at 20% and 40% to have a comparison of each element in two different percentages (H₃PO₄) 20%, (H₃PO₄) 40%, (KOH) 20%, (KOH) 40% and (ZnCl₂) 20%, (ZnCl₂) 40%.

This method combines carbonization and activation, it is carried out simultaneously in two stages, since the precursor is mixed with activating agents that fulfill the function of acting as dehydrating and oxidizing agents at the same time, which results in the development of better porous structures in activated carbons. Among the chemical agents commonly used in this activation method are ZnCl₂, KOH, H₃PO₄, K₂CO₃ and H₂SO₄ (Ioannidou & Zabaniotou, 2007).

Maximum admissible values for wastewater treatment

The Decreto Supremo N.º 021-2009-VIVIENDA regulates non-domestic water discharges into the sanitary sewerage system and establishes the Valores Máximos Admisibles – VMA:

The Valores Máximos Admisibles – VMA are understood as that value of the concentration of elements or physical and/or chemical parameters, which characterize a non-domestic effluent, which is going to be discharged into the sanitary sewer network, which, when exceeded, causes immediate damage. or progressive to the infrastructure and equipment of wastewater treatment systems, and has negative influences on wastewater treatment processes. (p. 3)

The Regulation of the VMA (Decreto Supremo N.º 003-2011-VIVIENDA) establishes the monitoring program and the inspection and sanction procedure in the case of non-compliance due to a non-domestic discharge. The EPS must implement a system of supervision and monitoring of non-domestic discharges to verify compliance with the VMA regulations. It must comply with what is indicated in Table 2 and Table 3.

Table 2

VMA for industrial discharges to the sewerage - Appendix 1

Parameter	Units	Worth
DBO ₅	mg/L	500
DQO	mg/L	1000
TOTAL SUSPENDED SOLIDS	mg/L	500
OILS AND GREASES	mg/L	100

Table 3

VMA for industrial discharges to the sewer – Appendix 2

Parameter	Units	Worth
PH	-	6 - 9
temperature	-	< 35
settleable solids	mL/L/h	8,5
ammoniacal nitrogen	mg/L	80
sulfates	mg/L	500
full chrome	mg/L	10
arsenic	mg/L	0,5
boron	mg/L	4
lead	mg/L	0,5

Materials and methods

For this stage, the shell of the coconut endocarp was obtained through the process of breaking with a hammer and then it was cleaned and dried naturally in the sun in an approximate time of 3 to 4 days, then this input was burned. in an artisan oven in periods of 3 to 5 hours separately, which was then dried naturally and finally passed to a grinding stage.

This first process of burning, drying and washing is the physical process and then the chemical activation was carried out with three elements such as Phosphoric Acid (H_3PO_4), Potassium Hydroxide (KOH) and Zinc Chloride ($ZnCl_2$), the three at 20% and 40% concentration (Figure 1).

Figure 1

Chemical inputs H_3PO_4 - $ZnCl_2$ – KOH



As the next stage, the wastewater from the laundry was taken, after training by the laboratory to take the samples properly and in the respective containers (Figure 2).

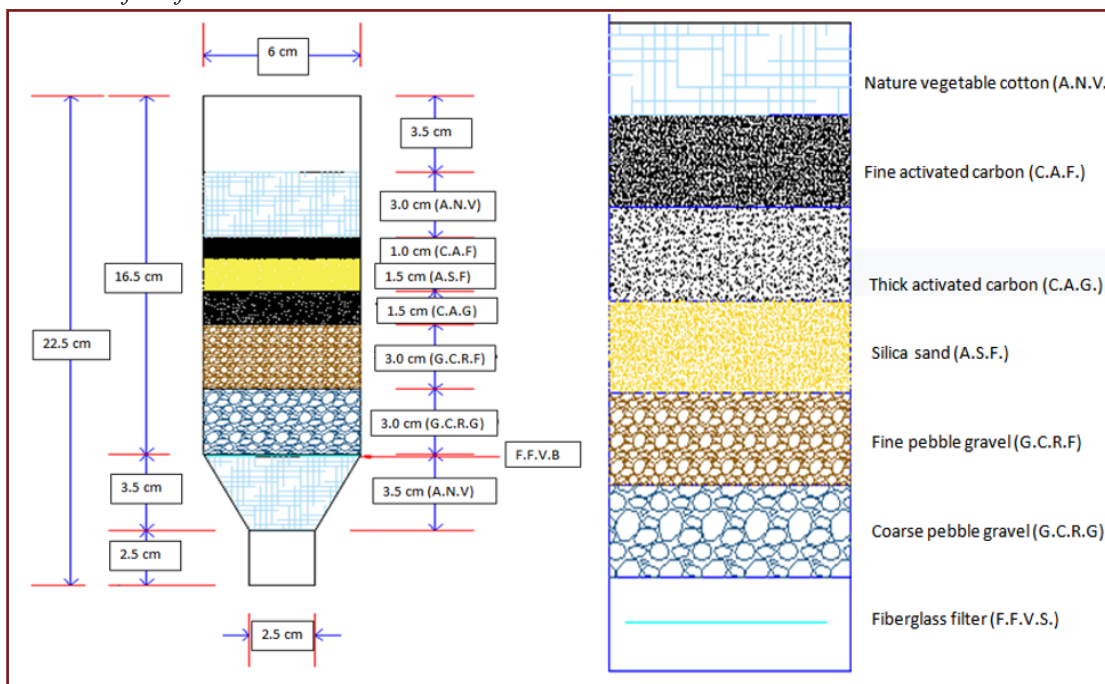
Figure 2

Training in laboratory Certifical and wastewater intake



Then, we proceeded to make the structure of the most effective filter, in which we based ourselves on turbidity and retention time, which was based on different layers (Figure 3).

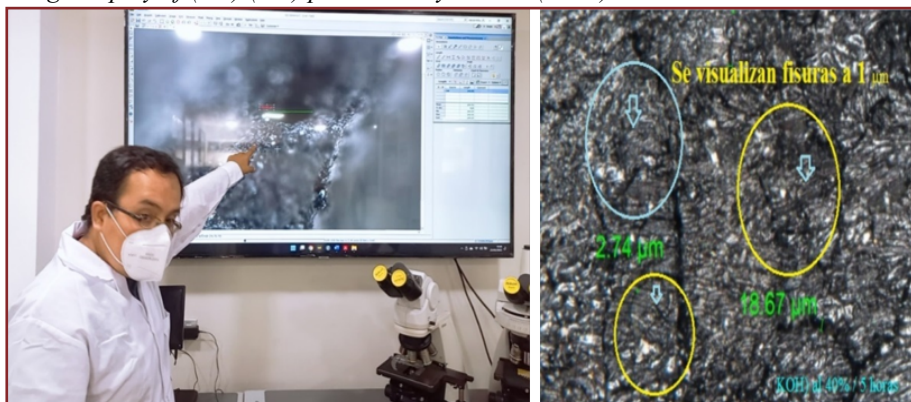
Figure 3
Structure of the filter used



Likewise, in the present work, the carbon body was visualized by means of a Nikon Digital Sight brand microscope, distributor of the brand in Peru - Nikon laboratories, through this high-power microscope it was possible to take photos and see the body of the carbon particle if there are caverns or porosity fissures and if the aforementioned was fulfilled if the chemical activation evolved in the development of the pores, that is why only the percentages of 20% and 40% of each were taken as a sample. one of the chemical elements (H_3PO_4), ($ZnCl_2$) and (KOH), considered time of 5 hours for each element we can see that with the chemical it presents caverns and fissures in units of (μm) of microns, the carbons activated with Hydroxide of Potassium (KOH) at 40% for 5 hours is seen with greater cracks in its body from $2.74 \mu m$ to $24.64 \mu m$, unlike (H_3PO_4), ($ZnCl_2$) in which the cracks were smaller.

Using the size of caverns and fissures obtained by physically and chemically activating activated carbon, electron microscopy showed that some have greater porosity, such as activated carbon with potassium hydroxide (KOH) at 40% concentration and burned for 5 hours, and activated carbon with phosphoric acid (H_3PO_4) at 40% concentration and burned for 5 hours (Figure 4).

Figure 4
Image display of (CA) (AG) potassium hydroxide (KOH)



The procedure was based on filtering the residual water from the laundry, for which 13 filters + 1 standard without treatment were used to determine the efficiency of removal of contaminants (Figure 5), for which we based ourselves on the coding performed in Table 4 and Table 5.

Table 3

VMA for industrial discharges to the sewer – Appendix 2

Parameter	Units	Worth
PH	-	6 - 9
temperature	-	< 35
settleable solids	mL/L/h	8,5
ammoniacal nitrogen	mg/L	80
sulfates	mg/L	500
full chrome	mg/L	10
arsenic	mg/L	0,5
boron	mg/L	4
lead	mg/L	0,5

Table 4

Chemical and microbiological parameters analyzed by filter

Parameters	Volume (ml)	Preservative	Maximum time
Oils and greases (AyG)	1000	H ₂ SO ₄	28 days
Biochemical Oxygen Demand (DBO ₅)	1000	--	24 hours
Chemical Oxygen Demand (DQO)	120	H ₂ SO ₄	28 days
Total Suspended solids (SST)	1000	--	7 days
Settleable solids (SS)	1000	--	7 days
Ammoniacal nitrogen (NH ₃)	500	H ₂ SO ₄	28 days
Sulfates (SO ₄)	250	--	28 days
Total metals	250	HNO ₃	28 days

Table 5

Filter coding by numbering

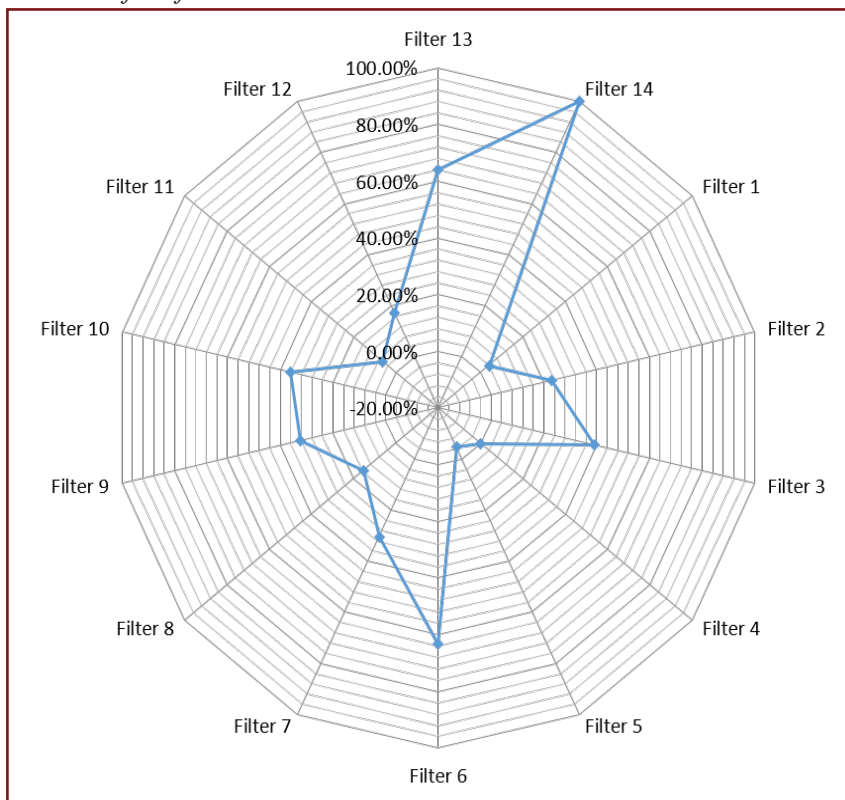
Filters	Numeration
Residual water from laundry	14
Physical activation	13
Chemical Activation (H ₃ PO ₄) – 20% - 3 Hours	1
Chemical Activation (H ₃ PO ₄) – 40% - 3 Hours	2
Chemical Activation (H ₃ PO ₄) – 20% - 5 Hours	3
Chemical Activation (H ₃ PO ₄) – 40% - 5 Hours	4
Chemical Activation (ZnCl ₂) – 20% - 3 Hours	5
Chemical Activation (ZnCl ₂) – 20% - 5 Hours	6
Chemical Activation (ZnCl ₂) – 40% - 3 Hours	7
Chemical Activation (ZnCl ₂) – 40% - 5 Hours	8
Chemical Activation (KOH) – 20% - 5 Hours	9
Chemical Activation (KOH) – 20% - 3 Hours	10
Chemical Activation (KOH) – 40% - 3 Hours	11
Chemical Activation (KOH) – 40% - 5 Hours	12

Results

The results obtained in this research work, it can be indicated that there are values that have decreased with respect to the pattern.

Regarding the parameter of oils and greases, a considerable removal was obtained, having an improvement in filter 13 with a removal percentage of 63.79% and in filter 6 a removal percentage of 63.22% (Figure 6).

Figure 6
Structure of the filter used



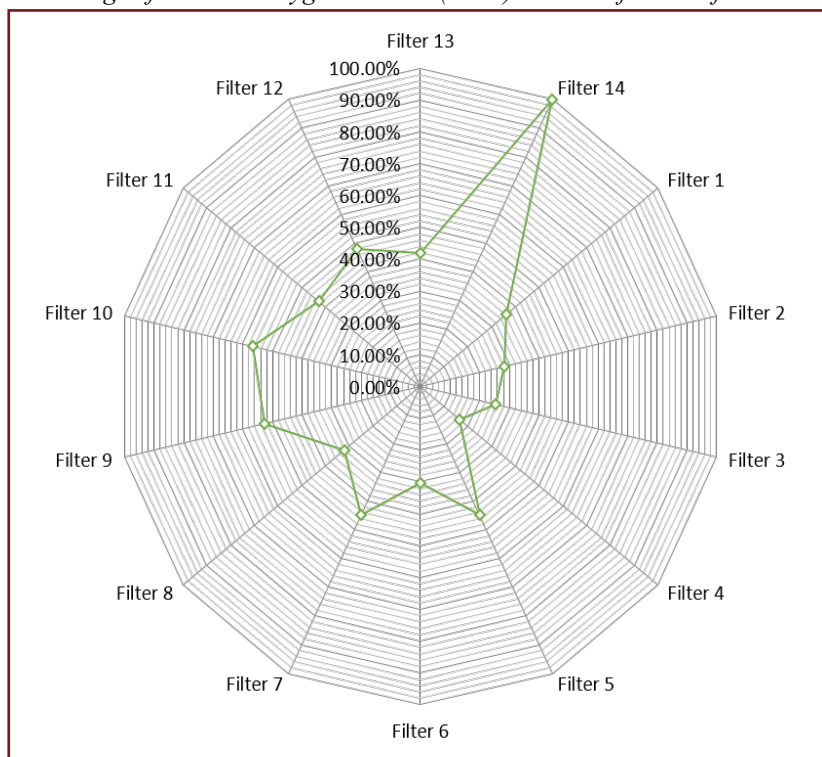
Regarding the biochemical oxygen demand (DBO₅) parameter, an intermediate removal was obtained, with an improvement in filter 1, with a removal percentage of 33.21% and in filter 9 a removal percentage of 63.22% (Figure 7).

Figure 7
Percentage of removal of biochemical oxygen demand (DBO₅) for each filter



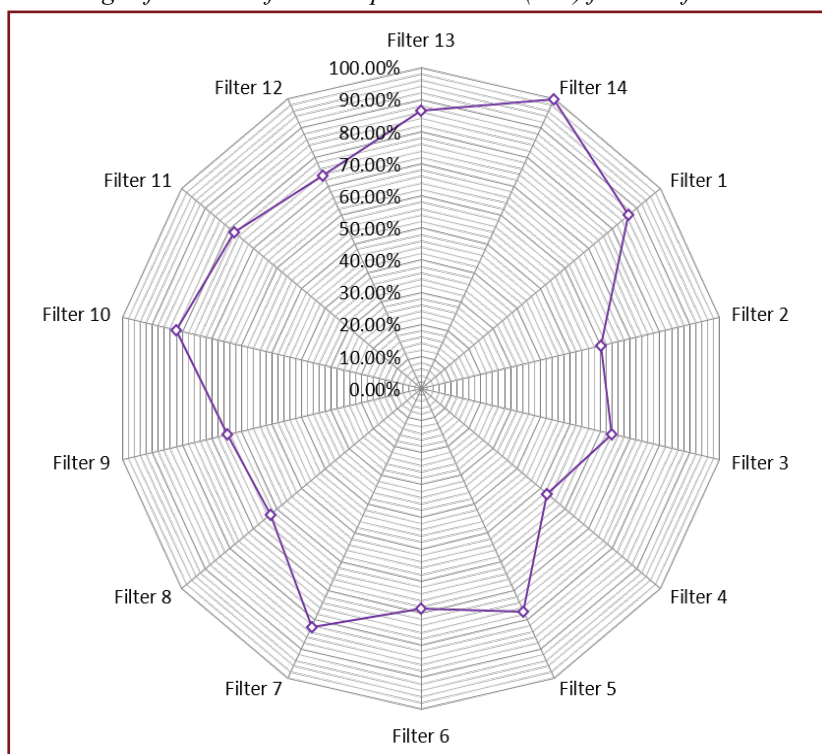
Regarding the chemical oxygen demand (COD) parameter, a considerable removal was obtained, having an improvement in filter 9 with a removal percentage of 52.66% and in filter 10 with a removal percentage of 56.56% (Figure 8).

Figure 8
Percentage of chemical oxygen demand (COD) Removal for each filter



Regarding the total suspended solids (TSS) parameter, a considerable removal was obtained, having an improvement in filter 13 with a removal percentage of 86.47% and in filter 1 with a removal percentage of 86.82% (Figure 9).

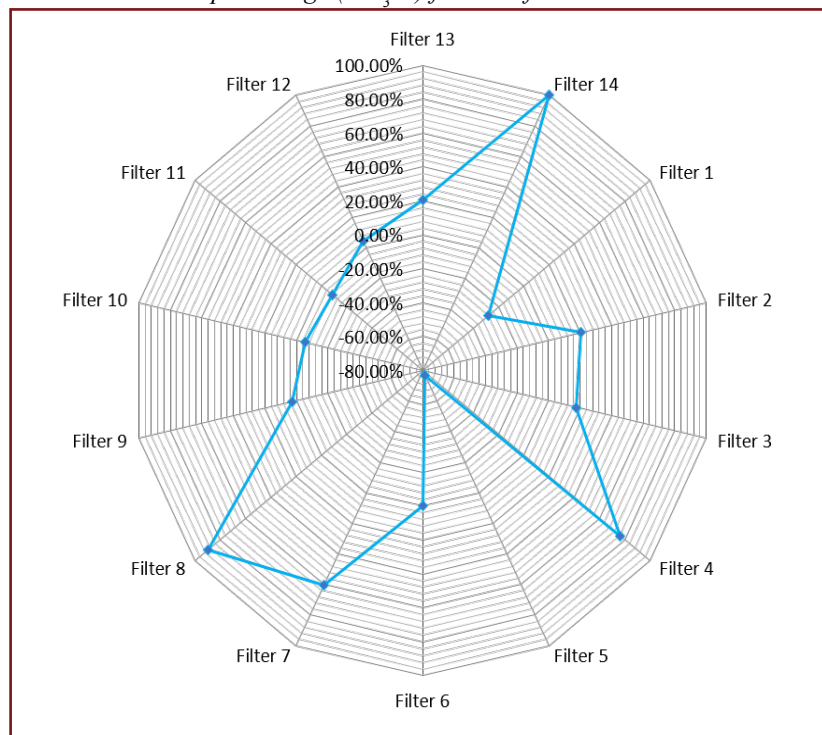
Figure 9
Percentage of removal of total suspended solids (TSS) for each filter



Regarding the ammonia ($\text{NH}_3\text{-N}$) parameter, a considerable removal was obtained, having an improvement in filter 4 with a removal percentage of 76.46% and in filter 8 with a removal percentage of 89.71% (Figure 10).

Figure 10

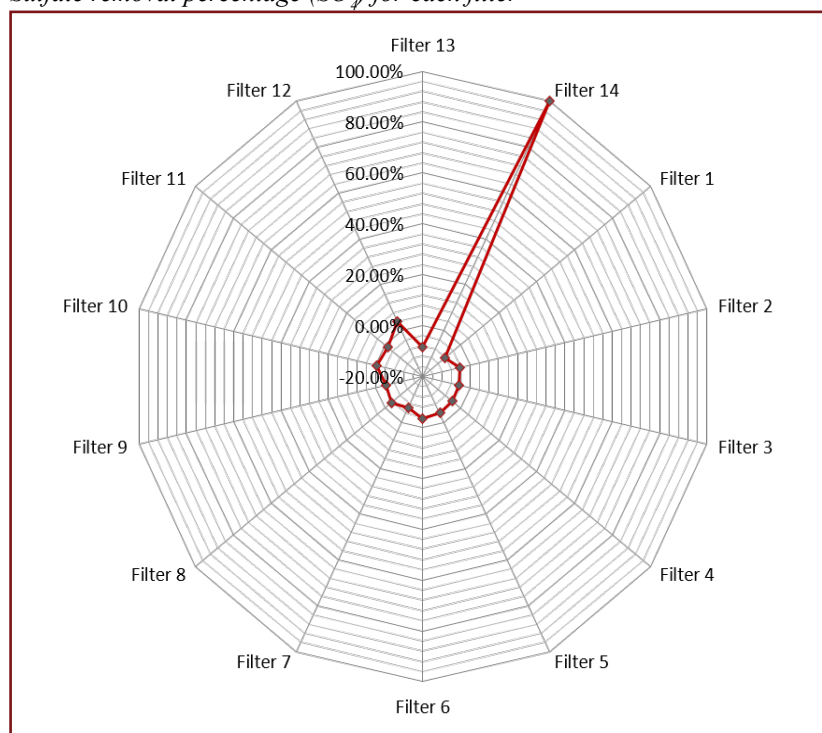
Ammonia removal percentage ($\text{NH}_3\text{-N}$) for each filter



Regarding the sulfates (SO_4) parameter, a low removal was obtained, with an improvement in filter 12, with a removal percentage of 86.82% (Figure 11).

Figure 11

Sulfate removal percentage (SO_4) for each filter



Regarding the parameters of heavy metals, it can be indicated as:

- Arsenic values are consistently below 0.0040 mg/L for all filters, including the standard sample.
- Boron values are consistently below 0.0022 mg/L for all filters, including the standard sample.
- Chromium values are consistently below 0.0040 mg/L for all filters, including the standard sample.
- Lead values are consistently below 0.0010 mg/L for all filters, including the standard sample.
- From the results obtained in this research work, it can be indicated that there are values that have decreased with respect to the pattern. Regarding the parameter of oils and greases, a considerable removal was obtained, having an improvement in filter 13 with a removal percentage of 63.79% and in filter 6 a removal percentage of 63.22% (Figure 3).
- Regarding the biochemical oxygen demand (DBO₅) parameter, an intermediate removal was obtained, with an improvement in filter 1, with a removal percentage of 33.21% and in filter 9 a removal percentage of 63.22% (Figure 4).
- Regarding the chemical oxygen demand (COD) parameter, a considerable removal was obtained, having an improvement in filter 9 with a removal percentage of 52.66% and in filter 10 with a removal percentage of 56.56% (Figure 5).
- Regarding the total suspended solids (TSS) parameter, a considerable removal was obtained, having an improvement in filter 13 with a removal percentage of 86.47% and in filter 1 with a removal percentage of 86.82% (Figure 6).
- Regarding the ammonia (NH₃-N) parameter, a considerable removal was obtained, having an improvement in filter 4 with a removal percentage of 76.46% and in filter 8 with a removal percentage of 89.71% (Figure 7).
- Regarding the sulfates (SO₄) parameter, a low removal was obtained, with an improvement in filter 12, with a removal percentage of 86.82% (Figure 8).
- Regarding the heavy metal parameters, it can be indicated as: Arsenic, the values are constantly below 0.0040 mg/L for all the filters, including the standard sample. Boron values are consistently below 0.0022 mg/L for all filters, including the standard sample. As the values are constantly below 0.0040 mg/L for all filters, including the standard sample. Lead values are consistently below 0.0010 mg/L for all filters, including the standard sample.

Discussion

The results obtained show the efficiency of filters based on coconut fibers for the treatment of wastewater from laundries. In comparison to other studies, no research has been carried out for wastewater from laundries, and it can be mentioned that It has removal efficiencies greater than 50% in oils and greases, DBO₅, COD, total suspended solids, ammoniacal nitrogen and sulfates. It can be indicated that this research helps the treatment of small companies that dump their raw wastewater into the sewage system using organic waste, which makes it sustainable.

The best filter structure was identified when filtering wastewater and being able to examine that the shortest filtration time was in proposed Filter 2 since it filtered the wastewater from laundry in 25 minutes and the water became clearer to the naked eye, unlike the other 3 filters that the filtration time was greater than 30 minutes and the color was cloudy. Therefore, it can be indicated that the proposed filter is efficient for the pretreatment of wastewater from laundries.

When testing the chemical and microbiological parameters of wastewater from laundries in the certifiical laboratory, removal efficiencies of 63.79% for oils and greases, 33.21% for biochemical oxygen demand, 56.56% for chemical oxygen demand, 86.82% for total suspended solids, 89.71% for ammonia, and 4.14% for sulfates were obtained. Therefore, it can be stated that the chemical and microbiological parameters of wastewater from laundries are removed through the use of organic filters.

The results obtained by Cueva and Lazarte (2021), using a biofilter with coconut shell activated carbon in the water of the Tablachaca River were efficient, initially there was an initial arsenic concentration of 0.0376 mg/L,

and using the filter figures lower than 0.008 mgAs/L were reached, so it was concluded that using coconut shell activated carbon as a bioadsorbent, the treated water meets the requirements established in the regulation Decreto Supremo N.º 003-2011-VIVIENDA. When compared with the results obtained in the present work, the arsenic values obtained are below 0.0040 mg/L for all the filters used in the present work, thus demonstrating that the use of coconut shell-based filters is efficient in removing arsenic.

The results obtained by Baharum et al. (2020), evaluated the adsorption of diazinon from aqueous solutions onto modified coconut shell biochar. Carbonized coconut shell biochar (BC1), activated coconut shell biochar (BC2), chemically modified phosphoric acid (BC3), and sodium hydroxide coconut shell biochar (BC4) were used, achieving a diazinon removal rate of up to 98.96% with BC3, the results obtained showed that BC3 is a highly efficient adsorbent. When compared with the results obtained in the present work, the values of removal of oils and fats was 63.79%, biochemical oxygen demand was 63.22%, chemical oxygen demand was 56.56%, total suspended solids was 86.22%, ammonia 89.71% and sulfates 86.82% thus demonstrating that it is efficient in removing contaminants in wastewater through the use of coconut shell-based filters.

The results obtained by Bravo and Garzon (2017), from activated carbon from coconut agro-industrial waste in the removal of contaminants in water, from the Pimpiguasi site, Portoviejo canton, activated by physical activation at a temperature of 700 °C for one hour. Physical analyzes were carried out on the water: suspended solids, residual free chlorine, turbidity, color and pH. The removal percentages of activated carbon as the most efficient (75.68%) in the removal of contaminants from water. When compared with the results obtained in the present work, the removal values of total suspended solids with the chemically activated filter for 5 hours with (ZnCl₂) - 40% concentration reached an efficiency of 89.71%, thus demonstrating that the use of coconut shell-based filters is efficient in the removal of total suspended solids.

Conclusion

It was possible to reduce the generation of solid waste from coconut shells in a proportion of 200 coconuts that generate approximately 24 kg of solid waste and at the same time natural activated carbon is generated that can be generated in a simple way for the population that has businesses of laundries and thus reduce their pollutants that are discharged into the public network, although it is true that there are parameters that are above what is indicated in the Standard, these are efficient in % of initial removal of the pattern that can later have another treatment or improve the filter.

The most appropriate filter structure was based on the observed turbidity and the retention time of approximately 25 minutes for each liter of gray water, materials such as A.N.V. (Natural Vegetable Cotton), P.F.W. (Whatman Filter Paper), G.C.R.G (Coarse Pebble Gravel), M.S. (Separation Mesh), G.C.R.F (Fine Pebble Gravel), C.A.G (Coarse Activated Carbon), A.S.F. (Fine Silica Sand), C.A.G (Fine Activated Carbon).

The removal efficiency achieved by each filter was acceptable in different efficiency percentages, filter 13 (Physical Activation) and filter 6 (Chemical Activation (ZnCl₂) - 20% - 5 Hours) the most efficient, with a removal of 63.79% and 63.22% of oils and greases with respect to the standard sample respectively, filter 1 (Chemical Activation (H₃PO₄) - 20% - 3 Hours) and filter 9 (Chemical Activation (KOH) - 20% - 5 Hours) the most efficient, with a removal of 33.21% and 32.69% of biochemical oxygen demand with respect to the standard sample respectively, filter 10 (Chemical Activation (KOH) - 20% - 3 Hours) and filter 9 (Chemical Activation (KOH) - 20% - 5 Hours) the most efficient, with a removal of 56.56% and 52.66% of chemical oxygen demand with respect to the standard sample respectively, filter 1 (Chemical Activation (H₃PO₄) - 20% - 3 Hours) and filter 13 (Physical Activation) the most efficient, with a removal of 86.82% and 86.47% of total suspended solids with respect to the standard sample respectively, filter 8 (Chemical Activation (ZnCl₂) - 40% - 5 Hours) - 20% - 3 Hours) and filter 4 (Chemical Activation (H₃PO₄) - 40% - 5 Hours) the most efficient, with a removal of 89.71% and 76.46% of ammonia with respect to the standard sample respectively and finally for the case of sulfates, a slight increase was seen in almost all the filters except for filter 12 (Chemical Activation (KOH) - 40% - 5 Hours), which obtained a removal of 4.14% with respect to the standard sample.

Recommendations

- Carry out experimental work using organic products, which, as can be seen in the present study, are efficient for the removal of chemical and microbiological parameters from wastewater.
- It would be important to analyze maintenance times over time intervals to determine the useful life of the filters.
- It is important to take the models made in the laboratory to scale in laundries or other industries, in order to determine other external factors that can influence the removal of chemical and microbiological parameters from wastewater.
- It should be mentioned that there are three parameters that are above what is stipulated in the (VMAs) such as DBO₅, COD and Sulfates, in a slight way, the thicknesses proposed in the present work must be analyzed so that it can be reached by below those stipulated in the standard, since the values are close.
- Evaluate the retention time for each filter to be analyzed since it is important for the wastewater filtration process.
- This work seeks to implement pre-treatment of wastewater from laundry or other related industries in order to reduce the contaminants that are discharged into the public network in order to avoid further contamination, which is why it is recommended that This work is a basis for future research work on the treatment of wastewater from different industries at low cost and sustainable.

References

- Agrafioti, E., Bouras, G., Kalderis, D., & Diamadopoulos, E. (2013) Biochar production by sewage sludge pyrolysis. *Journal of Analytical and Applied Pyrolysis*, 101, 72-78. <https://doi.org/10.1016/j.jaap.2013.02.010>
- Ahmad, A., Upadhyay, S., Srivastava, A., & Asger, A. (2021) Biofertilizers: A Nexus between soil fertility and crop productivity under abiotic stress. *Current Research in Environmental Sustainability*, 3. <https://doi.org/10.1016/j.crsust.2021.100063>
- Alonso, A., Blanco, J. A., & Puerta-Piñero, C. (2022). The aquatic and the terrestrial have a place in Ecosystems. *Ecosystems*, 31(2), 2414-2414. <https://doi.org/10.7818/ECOS.2414>
- Baharum, N., Nasir H., Ishak, M., Isa, N., Hassan, M., & Aris, A. (2020). Highly efficient removal of diazinon pesticide from aqueous solutions by using coconut shell-modified biochar. *Arabian Journal of Chemistry*, 13. <https://doi.org/10.1016/j.arabjc.2020.05.011>
- Bastidas, M., Buelvas, L., Márquez, M., & Rodríguez, K. (2010). Activated carbon production from carbonaceous precursors of the Department of Cesar, Colombia. *Technological Information*, 21(3), 87–96. <https://dx.doi.org/10.4067/S0718-07642010000300010>
- Centro Nacional de Planeamiento Estratégico [CEPLAN]. (2020). *Informe Nacional del Perú 2020: la protección de la vida en la emergencia y después*. <https://www.gob.pe/institucion/ceplan/informes-publicaciones/925877-informe-nacional-del-peru-2020-la-proteccion-de-la-vida-en-la-emergencia-y-despues>
- Colantoni, A., Evic, N., Lord, R., Retschitzegger, S., Proto, A., Gallucci, F & Monarca, D. (2016) Characterization of biochars produced from pyrolysis of pelletized agricultural residues. *Renewable and Sustainable Energy Reviews*, 64, 187-194. <https://doi.org/10.1016/j.rser.2016.06.003>
- Corregidor, C., Rocha, B., Chirivi, J., & Gómez, G. (2023). Matriz unificada para la evaluación del impacto ambiental; estudio de caso del río Chicamocha. *Revista Facultad De Ingeniería Universidad De Antioquia*, (111), 76–87. <https://doi.org/10.17533/udea.redin.20230316>
- Corregidor, C., Rochal, B., Chirivi, J., & Gómez, G. (2023). Unified matrix for environmental impact assessment applied to water resources, Chicamocha River case study. *Faculty of Engineering Magazine University of Antioquia*, (111), 76–87. <https://doi.org/10.17533/udea.redin.20230316>

- Cueva, P., & Lazarte, D. (2021). *Biofilter with activated carbon from coconut shell for arsenic removal from the Tablachaca River water; Ancash – 2021* [Bachelor's thesis, Universidad César Vallejo]. Repositorio UCV. <https://hdl.handle.net/20.500.12692/66730>
- Decreto Supremo N.º 003-2011-VIVIENDA. *Reglamento del Decreto Supremo N°021-2019-vivienda, que aprueba los valores máximos admisibles de las descargas de aguas residuales no domesticas en el sistema de alcantarillado sanitario* (8 de marzo de 2023). <https://www.gob.pe/institucion/sedaayacucho/normas-legales/3979365-003-2011-vivienda>
- Decreto Supremo N.º 021-2009-VIVIENDA. *Aprueban Valores Máximos Admisibles (VMA) de las descargas de aguas residuales no domésticas en el sistema de alcantarillado sanitario* (8 de marzo del 2023). <https://www.gob.pe/institucion/sedaayacucho/normas-legales/3979411-021-2009-vivienda>
- Ighalo, J.O., & Adeniyi, A.G. (2020). Adsorption of pollutants by plant bark derived adsorbents: An empirical review. *Journal of Water Process Engineering*, 35, 10122. <https://doi.org/10.1016/j.jwpe.2020.101228>
- Ioannidou, O., & Zabaniotou, A. (2007). Agricultural residues as precursors for activated carbon production – A review. *Renewable and Sustainable Energy Reviews*, 11(9), 1966-2005. <https://doi.org/10.1016/j.rser.2006.03.013>
- Johari, K., Alias, A.S., Saman, N., Song, S.T., & Mat, H. (2014). Removal performance of elemental mercury by low-cost adsorbents prepared through facile methods of carbonisation and activation of coconut husk. *Waste Management & Research: The Journal for a Sustainable Circular Economy*, 33(1), 81–88. <https://doi.org/10.1177/0734242X14562660>
- Lua, A. C., & Yang, T. (2004). Effect of activation temperature on the textural and chemical properties of potassium hydroxide activated carbon prepared from pistachio-nut shell. *Journal of colloid and interface science*, 274(2), 594–601. <https://doi.org/10.1016/j.jcis.2003.10.001>
- Mohan, D., Sarswat, A., Sik, Y., & Pittman Ch. (2014). Organic and inorganic contaminants removal from water with biochar, a renewable, low cost and sustainable adsorbent – A critical review. *Bioresource Technology*, 160, 191-202. <https://doi.org/10.1016/j.biortech.2014.01.120>
- Peña, K., Giraldo, L., & Moreno, J. (2012). Preparation of activated carbon from orange peel by chemical activation. physical and chemical characterization. *Colombian Chemistry Magazine*, 41(2), 311-323. http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S0120-28042012000200010&lng=en&tlng=es
- Pérez, Y., Cortés, D., & Jauregui, U. (2022). Constructed wetlands as an alternative for wastewater treatment in urban areas: a review. *Ecosystems*, 31(1). <https://doi.org/10.7818/ECOS.2279>
- Rizwan, M., Ali, S., Qayyum, M.F., Ibrahim, M., Zia, M., Abbas, T., & Sik, Y., (2016). Mechanisms of biochar-mediated alleviation of toxicity of trace elements in plants: a critical review. *Environmental Science and Pollution Research*, 23, 2230–2248. <https://doi.org/10.1007/s11356-015-5697-7>
- Salas, D., Zapata, M., & Guerrero, J. (2007). Cost model for wastewater treatment in the region. *In Scientia et Technica*, 1(37), 591–596. <https://revistas.utp.edu.co/index.php/revistaciencia/article/view/4191>
- Sujiono, E.H., Zabrian, D., Zurnansyah, Mulyati, Zharvan, V, Samnur & Humairah, N.A (2022), Fabrication and characterization of coconut shell activated carbon using variation chemical activation for wastewater treatment application. *Results in Chemistry*, 4, 100291. <https://doi.org/10.1016/j.rechem.2022.100291>
- Superintendencia Nacional de Servicios y Saneamiento [SUNASS]. (2015). *Diagnosis of the wastewater treatment plants in the scope of operation of the entities that provide sanitation services*. <http://www.sunass.gob.pe/doc/Publicaciones/ptar2.pdf>

- United Nations Educational, Scientific and Cultural Organization [UNESCO]. (2019) *World water development report 2019: leaving no one behind*. <https://unesdoc.unesco.org/ark:/48223/pf0000367306>
- Valladares, M., Valerio, C., De la Cruz, P., & Melgoza, R. (2018). Non-conventional absorbers: sustainable alternatives for wastewater treatment. *Revista Ingenierías Universidad De Medellín*, 16(31), 55–73. <https://doi.org/10.22395/rium.v16n31a3>
- Wu, H., Chen, R., Du, H., Zhang, J., Shi, L., Qin, Y., Yue, L., & Wang, J. (2018). Synthesis of activated carbon from peanut shell as dye adsorbents for wastewater treatment. *Adsorption Science & Technology*, 37(1-2), 34-48. <https://doi.org/10.1177/0263617418807856>
- Xiang, H., Ren, G., Yang, X., Xu, D., Zhang, Z., & Wang, X. (2020) A low-cost solvent-free method to synthesize α -Fe₂O₃ nanoparticles with applications to degrade methyl orange in photo-fenton system. *Ecotoxicology and Environmental Safety*, 200, 110744. <https://doi.org/10.1016/j.ecoenv.2020.110744>
- Yaashikaa, P., Senthil, P., Sunita, V., & Saravanan, A. (2020) A critical review on the biochar production techniques, characterization, stability and applications for circular bioeconomy. *Biotechnology Reports*, 28, e00570. <https://doi.org/10.1016/j.btre.2020.e00570>
- Yamaguchi, N., Cusioli, L., Quesada, H., Camargo, M., Fagundes, M., Salcedo, A., Gutierrez, R., Fernandes, M., & Bergamasco, R. (2021). A review of Moringa oleifera seeds in water treatment: Trends and future challenges. *Process Safety and Environmental Protection*, 147, 405-420. <https://doi.org/10.1016/j.psep.2020.09.044>