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Treatment of laundry wastewater (LWW) using different filters media

Layla Abdulkareem Mokif [1] **Noor Alaa Abdulhusain[2]**

[1,2] Environmental research and studied center, University of Babylon, Iraq

[1]ORCID:https://orcid.org/0000-0001-8291-9122[2]ORCID:https://orcid.org/0000-0003-1166-9212

***Corresponding author:**laylaabdulkareem86@yahoo.com

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Abstract:

In this study, the reuse of household wastes as filter media was explored for treating laundry wastewater in addition to sand media. These wastes included walnut husks and aluminum foil used in pharmaceutical drug packaging. For eight days, the filtration system operated at flow rates between 0.02 and 0.04 m3/h. PO4, TDS, and TSS were the variables examined. The results demonstrate that compared to sand and walnut husk filters, aluminum foil filters were more successful in removing phosphate, total suspended solids, and total dissolved solids. The results showed that the wastewater's pH is naturally alkaline, measuring at 7.8, which is the typical guideline value for laundry wastewater. TDS and TSS values ranged (10400-8600) mg/L higher than the permissible limit. Maximum removal efficiency values were (72.55%, 49.67%, and 78.48) for (PO_4, TSS, and TDS) respectively for flow rate of0.02 m^3/h were accomplished by the suggested new aluminum foil filter.

Keywords: aluminum foil, filtration, walnut husks, laundry wastewater, sand filter.

Introduction

Effluents discharged from various sources of wastewater and containing harmful substances are one of the major sources of environmental pollution in the world and have negative effects on human health and the aquatic environment[1]. According to the World Health Organization, 2.4 billion people still lack access to adequate sanitation and 700 million people do not have access to drinking water [2]. In recent years, due to the population increasing and the scarcity of water resources, the human being has become a threat to the environment due to the pollution of water resources through various activities and the disposal of polluted water, including sewage and industrial wastewater into surface waters. Thus, wastewater not affect human health and the environment only, but rather than cause biological problems that affect all living creatures [3]. Many activities such as consumption of water and industrial activities lead to generating large quantities of wastewater which must be treated before being released into water systems. Such wastewater, if not adequately treated may cause risks to the aquatic environment because the pollutants particles may have carcinogenic and mutagenic effects [4]. Today laundry has become an important part of the humans life, and large quantities of water and various cleaning materials are consumed [5].Laundry wastewater is produced from the use of detergents, soaps and soda, which are used to remove grease and dirt from clothing[6;7].

The increase in the laundry numbers caused an increase in the using detergents. The main component of the detergent is natrium tripoly-phosphat which act as surfactant, so most the wastewater produced from washing is containing phosphates. Most of these laundries discharged polluted water to surface water without treatment [8].The Most important components of laundry wastewater, are surfactant and detergent that are difficult to decompose and result in foaming which affects the normal use of water in addition to affecting the operation of the wastewater treatment plants. Pollutants with high in concentrations present in laundry wastewater such as oils and greases, TSS and nutrients, such as phosphates and nitrogen, which exceed the permissible limits for disposal. These pollutants, if discarded untreated, may cause eutrophication and oxygen deficiency. Therefore, laundry wastewater must be treated before it is released into the environment [9–11].

Laundry wastewater quality relied on the types of materials used in washing. In general wastewater consist of dissolved and solid matters that have been resulted from fabrics treatment as well as cleaning agents [12]. Discharging untreated laundry wastewater contained considerable contaminants with high concentrations such as suspended solids, oil and grease phosphorus and nitrogen, will exceed the discharge standards for municipal wastewater. In addition, it will cause an acceleration of eutrophication and excessive depletion of oxygen resources, and this shows more attention for implementation of environmental standards for discharging of laundry wastewater and reuse[13]. Literature show many different methods and techniques have been used for treating laundry wastewater in addition to the use of household wastes as filter medium or as adsorbents.

Wastewater filtration is one of the alternative engineering designs that can be considered in waste water treatment flow charts to meet specific effluent quality objectives [14]. One of the earliest processes used for treatment of water and wastewater is sand filter and it’s considered as a significant method for purification of water over the world. Low cost of operating and simplicity are major advantages of sand filter compared with other methods of water treatment. Also sand filter produces effluent with excellent quality and without any use of chemical treatment [15,16]. In this study using household wastes including agriculture and pharmaceutical drug packaging wastes such as husks of walnut and aluminum foil respectively have been investigated for treatment of some pollutants exiting in laundry wastewater.

Many scientists are concerned about the escalating water problems around the globe. In impoverished nations, there is a significant lack of affordable water, therefore using techniques for wastewater treatment can reduce this problem. Each day, LWW is produced, and several wastewater treatment studies have been undertaken to produce appropriate approaches [17].The commercial laundry sector is a hugely significant yet sadly underappreciated business sector. The commercial laundry industry has been significantly impacted over the past few decades by changing chemical limitations, sustainability-based laws, and safety requirements, particularly as demand for environmental considerations such as wastewater treatment and recycling has increased [18]. Table (1) reveal different filter media in previous studies employed for the treatment LWW. The treatment of laundry water is today a very tough challenge because of the increasing population growth and the absence of infrastructure upgrades, especially in the area of sanitation. Laundry wastewater qualities, in particular the need for treatment, are critical when assessing the viability of reuse [19]. Suspended solids, salts, minerals, organic materials, and pathogens from residual laundry detergent and fabric softener residues are present in different amounts in laundry wastewater [20]. (0.017 - 0.33) g/L of suspended solids in grey water have been measured and published in the literature. Laundries and kitchens contributed the greatest value of which [21]. Average total suspended solids concentration ranged (0.08 g/L - 0.16)g/L revealed in previous studies [22;23].

The phenomenon of eutrophication is carried on by an accumulation of phosphates in water bodies and significantly improves the fast growth of algae and aquatic plants [24,25]. The initial concentration of phosphate and dissolved solid in laundry wastewater recorded in some previous studies were (2.02 mg/L - 18.4 mg/l) and (3,150 mg/L) respectively [26–28]. The use of packaging and packing materials has significantly expanded throughout time. This has resulted in an increase in packaging waste and difficulties with waste management, [29]. The most popular packing material is aluminum foil because of its protective qualities against the effects of moisture, heat, and light. Due to its light weight, aluminum significantly reduces the cost of product shipping and gives in a nice appearance at a somewhat lower cost [30].

Table 1: different filter media for treatment of some pollutant in LWW adopted in some previous studies

Filter media type	**Flow rate**	**Target parameters and pollutants in LWW**	**References**
combination of sand filter, bio-char and teff straw media	6.23–17.58 m3/day	COD, TS , BOD, TDS, TSS ,DO	[25]
Sand filter	-	COD, TS , BOD, TDS, TSS, iron, Cu, Mg	[27]
volcanic rock and Canna plants filter	240 ml/min	COD, BOD, TDS, TSS, total P	[31]
Ceramic Tile Waste filter	-	COD, PO4, Na	[32]
Granular Activated Carbon (GAC) filter Sand filter	15 m3/h	COD, TSS, pH, turbidity , conductivity ,ammonia nitrogen , total surfactant , total phosphorous	[33]
Silica filter activated carbonfilter and ceramic filter	-	TDS, EC, COD and BOD5	[34]
Biosand Filter		pH	[35]
Anaerobic filter	-*	COD, BOD5, ammoniacal N (NH4–N), nitrate (NO3–N), nitrite (NO2–N), orthophosphate (PO4–P) and pH	[36]

*(-) this means there is no specified value of flow rate had been found in specified references

The majority of the wastewater from laundry is discharged into the municipal wastewater system, which can a lot of save water can be save if the effluent can be recycled after treatment [37]. A variety of methods are used for treating or reusing the laundry wastewater, including biological processes, physicochemical processes, filtration, and adsorption, for removing or lowering pollutants in LWW [38].

The researchers examined many physical and biological technologies to treat laundry wastewater, it was discovered that the usage of membrane technology was vital to produce high-quality purified water that can be reused more extensively for various uses, including the washing system. [39]. Also LWW was treated using electrocoagulation by using regulated voltage to oxidize aluminum metal, which results in a variety of aluminum hydroxyl $Al(OH)_3$species capable of adsorbing contaminants from the wastewater [40]. Vertical-Sub-surface Flow is one method for eliminating toxic chemicals from laundry effluent. Constructed a wetlands system employing volcanic rocks as a growing medium for plants and the plants themselves as filters. Adsorption of LWW is still regarded as an effective and affordable approach [41]. For the treatment of household laundry wastewater, the electrocoagulation procedure was chosen as a potential environmentally friendly method. Various techniques for treating wastewater, particularly, include employing water hyacinth, alum coagulant, zeolite media, as well as sand and activated charcoal were employed for laundry wastewater reuse. BOD, COD, and TSS in LWW can be reduced by using a filter media combination of silica sand, zeolite, and activated charcoal [42].

Materials and Methods

In this study, the reuse of household wastes such as husks of walnut and aluminum foil used in pharmaceutical drug packaging as a filter media was investigated in addition to the sand media. A household wastes were prepared by cleaning the waste and grinded as shown in Fig. (1a and 1, b).

Fig .1: Filter media (a) aluminum foil, (b) husk of walnut

A pilot plant has been designed consisting of three columns filters, the first column is the sand filter, the second column is the aluminum foil filter, and the last column is the walnut husks filter, and the filter media has been arranged as shown in Figure (2). The samples of the laundry wastewater used for investigation analysis were obtained from local household laundries. The filter system was running for eight days, with a flow rate of (0.02 m^3/h and 0.04 m^3/h) with pH of

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7.8. Samples were drawn for each running day for each filter. Parameters analyzed were (PO_4, TDS and TSS). The samples were analysis according to standard methods for the examination of water and wastewater [43] and instrument used in this work is UV- visible spectrophotometer as shown in Figure (3a, 3b).

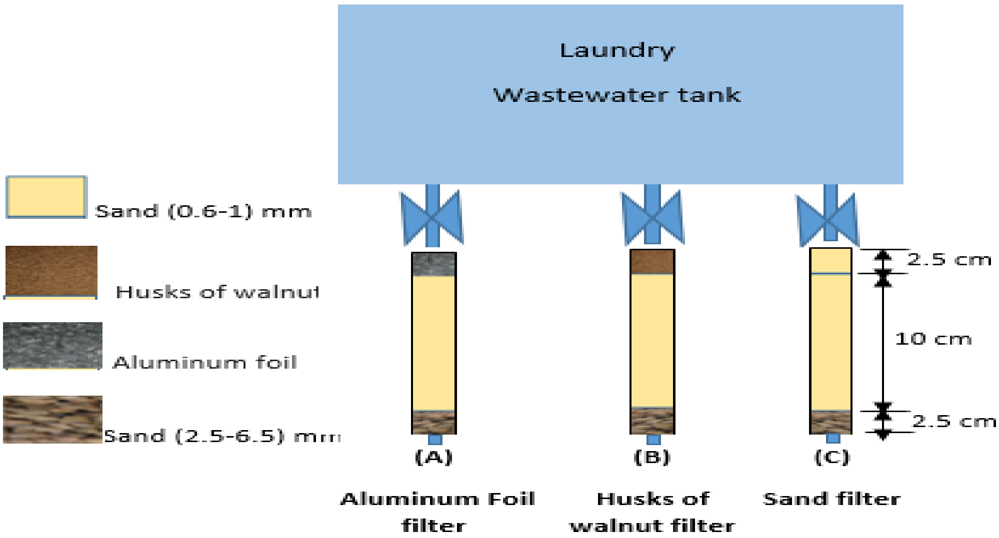

Fig. 2: Pilot Plant

Fig. 3: (a) samples, (b) UV-VIS spectrophotometer

Results and discussion

The investigation demonstrated the pH of the wastewater is 7.8 and within the range of 6.0 to 9.0, which is the typical guideline value for laundry wastewater. TDS and TSS ranges value were (10400, 8600) mg/L which is higher than the permissible limit (1000-2000 mg/L) and (10-30 mg/L) of TDS and TSS respectively. The increase in solid content regarding to the contamination from soap and dirt in LWW [44]. Figure 4 (A and B) shows the removal efficiency of phosphate from laundry wastewater of three filters with pH of 7.8.

Removal of Phosphate

Maximum values of removal efficiency of phosphate (PO_4) for sand filer, husks of walnut filter and aluminum foil filter were (44.54 %, 55.66% and 72.55%) respectively. Minimum removing efficiency values of phosphate for sand filer, husks of walnut filter and aluminum foil filter were (26.35%, 20.11% and 34.6%), respectively with flow rate of 0.02 m^3/h. Maximum values of removal efficiency of phosphate (PO_4) for sand filer, husks of walnut filter and aluminum foil filter were (42.84%, 50.87% and 70.71%) respectively Minimum removing efficiency values of phosphate for sand filer, husks of walnut filter and aluminum foil filter were (21.5%, 18.62% and 28.4%) respectively with flow rate of 0.04 m^3/h. Both the filter depth and the daily hydraulic load proved to have a significant impact on the removal of orthophosphate. Sorption in the filter media is determinate by capacity of the retention of the porous media [45].The outcomes revealed that the efficacy of investigated filters media for removing phosphate were compatible with the results of Mažeikien˙ and Šarko 2022[46].

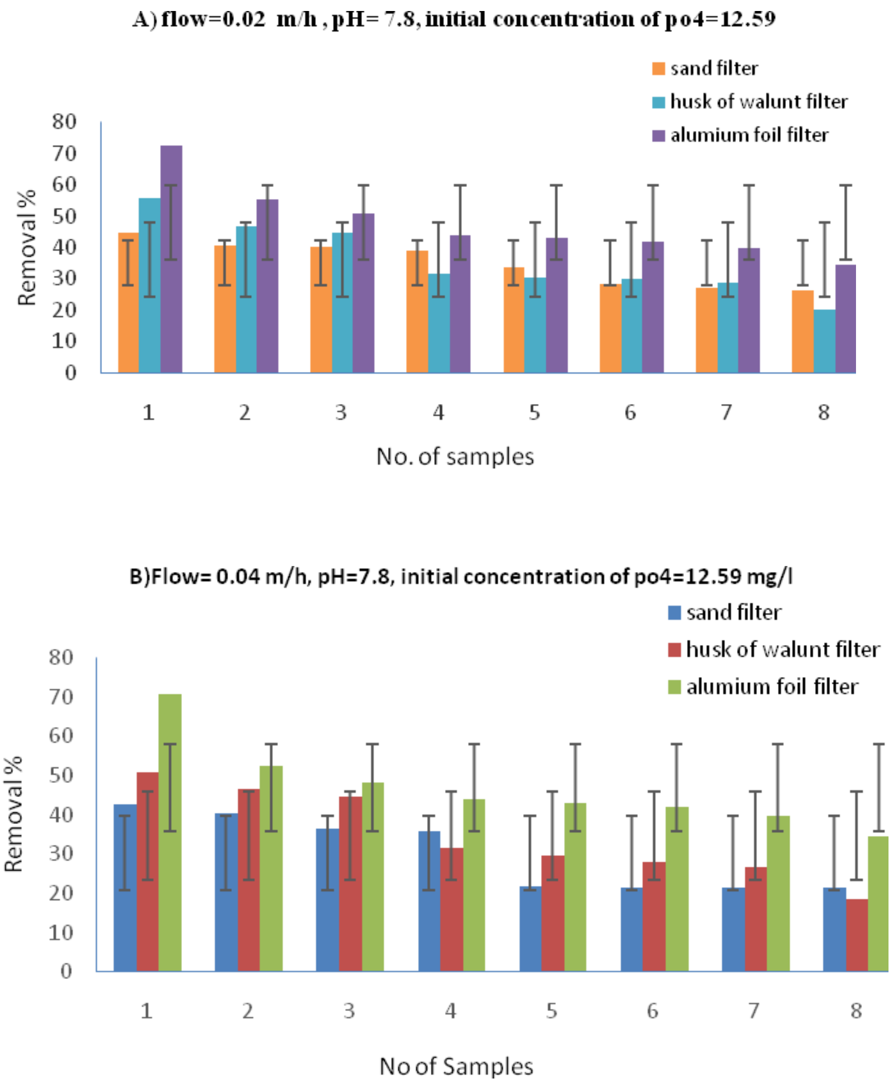

Fig. 4: Removal efficiency of phosphate A) flow 0.02m^3/h, B) flow 0.04m^3/h

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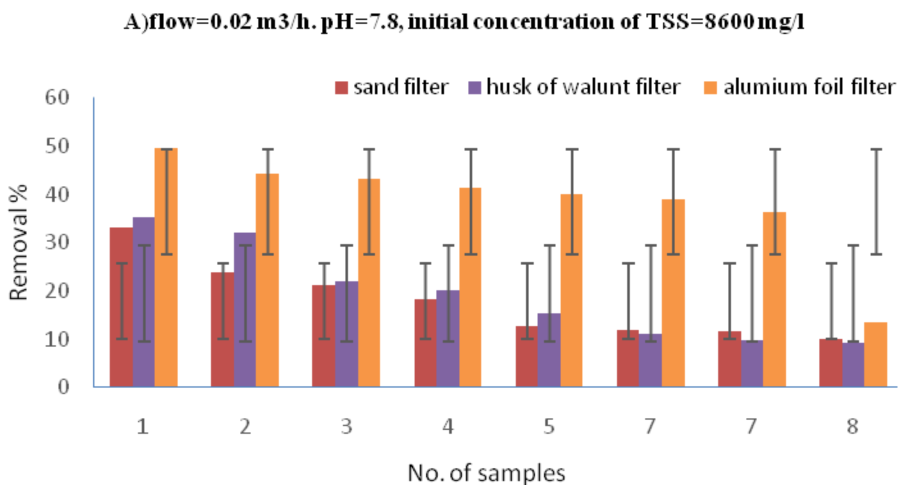
Removal of Total Suspended Solids

Figure 5(A and B) illustrate removal efficacy of total suspended solids (TSS) from laundry wastewater for three filters. Maximum values of removal efficiency of total suspended solids for sand filer, husks of walnut filter and aluminum foil filter were (33.11%, 35.44% and 49.67%), respectively. Minimum removing efficiency valuesof total suspended solids for sand filer, husks of walnut filter and aluminum foil filter were (10.13%, 9.18%, 13.44%), respectively with flow rate of flow 0.02m^3/h. Maximum values of removal efficiency of total suspended solids for sand filer, husks of walnut filter and aluminum foil filter were (27.91%, 32.56% and 44.19%), respectively. Minimum removing efficiency values of total suspended solids for sand filer, husks of walnut filter and aluminum foil filter were (5.83%, 6.98%, 9.3%), respectively with flow rate 0.04m^3/h. The outcomes showed that the concentration of total suspended solid (TSS) decreased due to the power of adsorption of different filter media used in study which are able to absorb suspended solids - density in wastewater [47]. The outcomes revealed that the efficacy of investigated filters media for removal of TSS from wastewater were agreement with Bali and Gueddari [48]



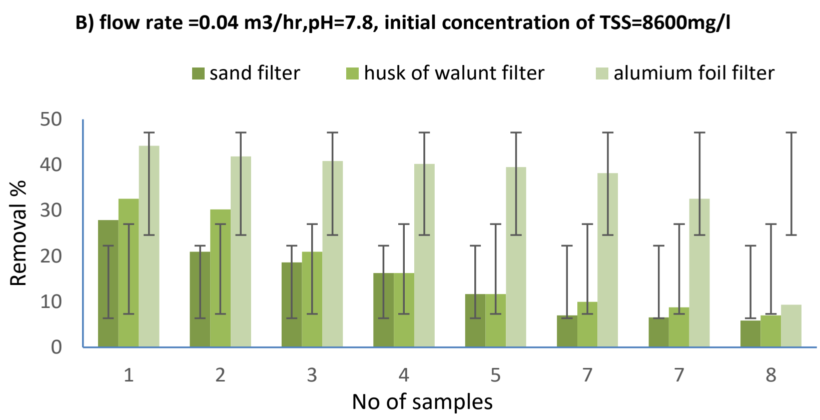


Fig.5: Removal efficiency of TSS A) flow 0.02m^3/h , B) flow 0.04m^3/h

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Removal of Total dissolved Solids

Figure 6(A and B) shows the removal efficacy of total dissolved solids (TDS) from laundry wastewater for three filters. Maximum values of removal efficiency of total dissolved solids for sand filer, husks of walnut filter and aluminum foil filter were (66.22%, 55.1% and 78.48%), respectively. Minimum removing efficiency values of total dissolved solids for sand filer, husks of walnut filter and aluminum foil filter were (14.44, 47.55% and 68.67 %), respectively with flow rate of 0.02 m^3/h. Maximum values of removal efficiency of total dissolved solids for sand filer, husks of walnut filter and aluminum foil filter were (55.72%, 50% and 73.08%), respectively. Minimum removing efficiency values of total dissolved solids for sand filer, husks of walnut filter and aluminum foil filter were (8.6%, 46.3% and 67.6 %), respectively with flow rate 0.04 m^3/h. The majority of the dissolved particles in laundry wastewater are sodium-based detergents and water-soluble whitening and favorable and simplest technique for TDS removal is filtration according literature [49;50]. The outcomes revealed that the efficacy of investigated filters media for removing TDS from wastewater were good comparing with Egathambal *et al.* [51].

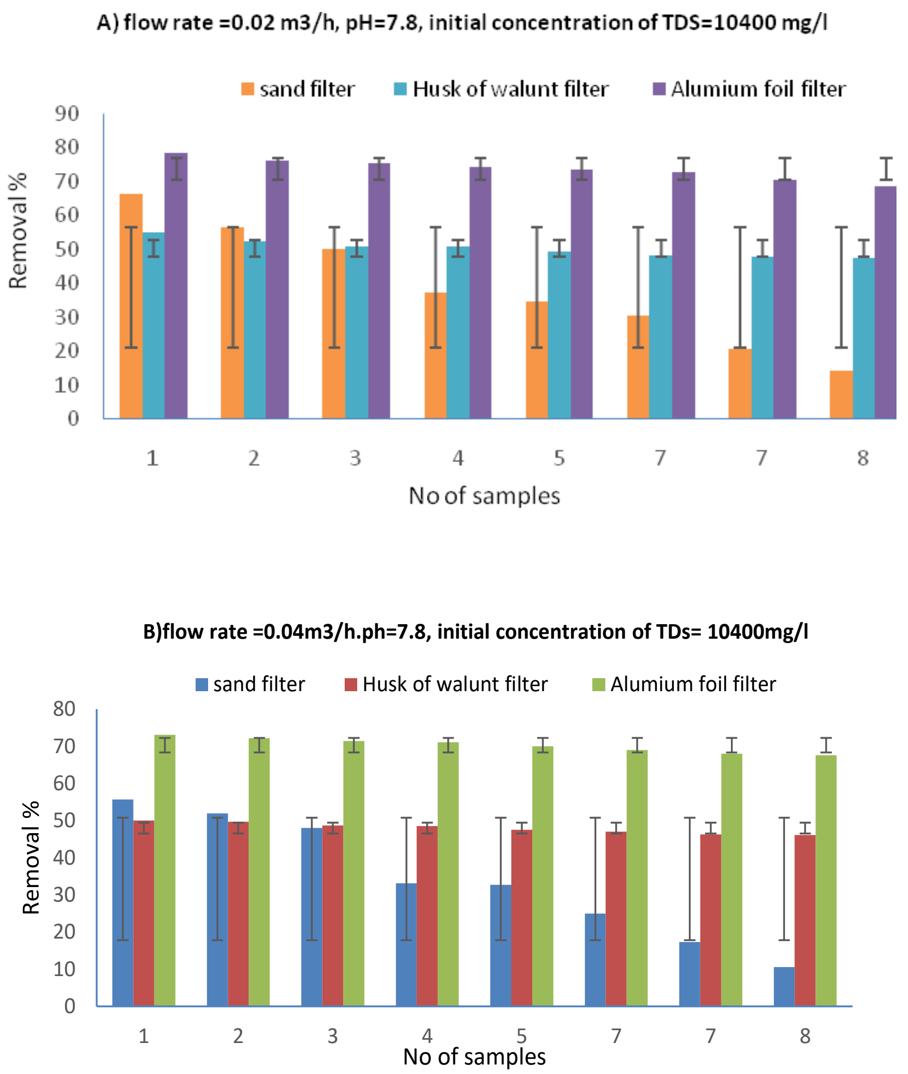

Fig. 6 : Removal efficiency of TDS A) flow 0.02m^3/h , B) flow 0.04m^3/h

Conclusions

The outcomes of the present study showed that aluminum foil filters were more effective at eliminating phosphate, total suspended solids, and total dissolved solids than sand and walnut husk filters. The investigation found that the wastewater's pH is within the typical range of laundry effluent. The content of TDS and TSS were higher than the permissible limit.

Author Contributions Statement

Layla Abdulkareem Mokif (70%): experimental work design and implementation, data collection, writing the introduction, results discussion.

Noor Alaa Abdulhusain (30%): writing the introduction, funding

Declaration of competing interest

The author confirms that there was no competing interest with others.

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