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Efficient Treatment of Cattle Farm Wastewater: a Combined Approach using Natural Coagulants with Agricultural Waste Filtration

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Abstract

In the present study, a three-step experimental process was used to treat the dairy cow farm wastewater (DCFW) from the Rami farm in Balenda town, Barzan. The initial phase was sedimentation, which was followed by coagulation using different concentrations of natural Zeolite (Z) and Moringa oleifera seeds (MO). The final step was filtering using physically processed rice straw (RS). Each stage evaluated separately by determining removal percentages of pollutant, and the entire process was then evaluated using the same method. Optimum concentrations for each coagulant used were 0.7 g.500 ml^{-1} for Z and 0.5 g.500ml-1 for MO, according the jar-test results. The maximum removal efficiency for COD, BOD, TSS, TDS, EC, TN, and TOC was obtained with 0.7 g.500 ml^{-1} for Z during the coagulation process. On the other hand, MO showed an improved removal efficiency for TP at 0.5 g.500 ml^{-1} . According to the related results MO outperformed the natural coagulant Z in the removal of phosphorus, while Z was more effective in eliminating a broader range of organic and inorganic pollutants. A comprehensive evaluation of the whole treatment system, involving filtration using physically activated rice straw (RS), revealed optimal removal performance when Z at 0.7 g.500 ml^{-1} was employed as the coagulant. Attained removal percentages were 75.91% for COD, 80.28 % for BOD, 79.86 % for TSS, 71.42 % for TDS, 68.74% for EC, 75.99% for TN, and 73.84 % TOC. Conversely, the specific combination (0.5 g.500 ml^{-1} MO + RS filtration) consistently yielded the highest TP removal efficiencies of 72.59 %.

1. Introduction:

The dairy industry is essential for the agrifood sector in Kurdistan (Iraq), since the country has become self-sufficient in milk production and cattle breeding has increased steadily, intensive livestock farming must be expanded. Milk processing is typically carried out using standard methods to ensure high quality, but the amount of waste generated daily by livestock farming is one of the largest environmental concerns in intensive management systems. Thus, a single unit with a thousand animals in confinement may produce an ordinary organic waste load of 750 kilograms per day[1],[2].

The water from the washing of confinement facilities that contain urine and feces constitutes the majority of the wastewater from the dairy cattle farm (DCFW). This water can mix with surface water and have unfavorable environmental effects, such as the highest concentration of COD and BOD and the depletion of dissolved oxygen (DO). Other pollutants include phosphate (P), nitrogen (N), oil and grease, nutrient enrichment, total dissolved solids (TDS), total suspended solids (TSS), and unpleasant odors have increased [3], [4].

Furthermore, untreated DCFW discharge into water bodies may raise coliform concentrations, lowering the quality of the water for irrigation and human usage [5]. Therefore, it is essential for this particular type of wastewater to be treated before being released into lakes and rivers.

Dairy waste waters are treated using several types of aerobic and anaerobic techniques, such as the anaerobic sludge blanket (UASB), aerated lagoons, activated sludge process, batch reactor sequencing, trickling filters, anaerobic filters, etc. These methods continue to be costly, energy-intensive, and produce an excessive quantity of sludge [6]). A further option for treating DCFW is the physicochemical method, which uses coagulation-flocculation units and dissolved air flotation (DAF) to remove total suspended solids (TSS), colloids, turbidity, color, and lipids [7]. In wastewater treatment systems, coagulation-flocculation is the most popular, economical, and attractive new technology [8], especially because of its affordability and natural availability. Divalent, positively charged chemical substances like ferric chloride and aluminum sulfate are introduced during the conventional coagulation process, which has an adverse effect on the environment and human health. Toxic sludge, excessive chemical residues, and illnesses from extended exposure are the most common environmental impacts of using chemical coagulants [9].

Making changes to natural coagulants can reduce the damage to the environment and health hazards associated with the usage of chemical coagulants [10]. Interestingly, natural coagulants are safe and mostly made from plants that are readily and regularly accessible [11].

The use of natural coagulants as a practical substitute for chemical coagulants in the treatment of water and wastewater has been the subject of several recent works [12]. According to [13], Moringa oleifera seeds are regarded as one of the most promising natural coagulants. As a member of the Moringaceae family, Moringa oleifera flourishes in both tropical and dry environments [14]. Moringa oleifera seeds are a natural, biodegradable coagulant that is safe for humans and animals, according to several research [15]. The coagulant made from Moringa oleifera seeds is effective at removing heavy metals, turbidity, and microbes from water [16], as well as softening water [17],[18].

zeolites are a class of microporous sodium or calcium hydrated aluminosilicates that are created by joining oxygen atoms in silica (SiO44-) and tetrahedral alumina (AlO45-) [19]. A wide range of applications, including absorbability, water purification, coagulation activity, membrane separation, and antimicrobial activities, have been made possible by the fundamental properties of zeolites, such as their porosity and structural diversity [20],[21], uniform pore size and shape, cation mobility, and the hydrophilic and hydrophobic nature of the absorbents and absorbates [21], [22]. Numerous industrial, scientific, and environmental problems are still resolved with zeolites today [23].

natural zeolites are hydrophilic, cheap, have a big specific surface area, a significant ionic exchange capacity, and a structure with a lot of porous spaces [20]. Zeolites are classified into two primary categories: natural and synthetic [21], [24]. Mordenite, clinoptilolite, and chabazite are among the sedimentary and volcanic rocks that make up the bulk of natural zeolites [25]. On the other hand, synthetic zeolites are made by heating feldspar, soda ash, China clay, and other minerals [25],[26].

Zeolites like clinoptilolite are now often utilized in industrial production, wastewater treatment, grey water treatment, and catalytic processes because of their internal and external porosity [22]. Zeolites may be used to adsorb pollutants and remove metal ions from wastewater, as well as to remove contaminants, mainly ammonium, anions, phosphorus, and heavy metals.

Many forms of rural waste, such as rice straw, wheat straw, rice husks, maize straw, tree leaves, wood chips, and so on, are agricultural byproducts. This rural waste matter is frequently burned as a method of disposal, which is ecologically damaging and harmful to the atmosphere [27]. To tackle this issue, these waste products might be utilized in wastewater treatment. In Asia, Rice is an essential staple grain, playing a crucial role in regional food security. Across Southeast Asia, rice stands as the predominant agricultural crop [28]. Over time, rice production has grown quickly, which has also led to a rise in the amount of biomass known as ”waste” that is not edible [29]. Following harvesting, non-grain material, known as rice straw (RS), is separated from rice grain and remains as an agricultural residue. Rice straw (RS) is a byproduct of rice processing; it is mainly composed of 28–48% cellulose, 26.40% hemicelluloses, and 12.26% lignin; and is presented as the cell wall structure, 12.26% ash, 2.18% wax, and 9% silica [30]. RS is frequently used to increase soil fertility and in animal feed. It is relevant and opportune to look into its use as a natural adsorbent, given the volume of its production and its inexpensive cost.

To the best of the authors' knowledge, the comparison between the efficiency of Moringa oleifera seeds and zeolite, as examples of natural coagulants, in DCFW treatment, followed by filtration with physically treated rice straw, has not been previously investigated. Therefore, this study aimed mainly to assess the efficiency of using zeolites and Moringa oleifera seeds as green and environmentally friendly agents in the treatment of DCFW. Secondly, we wished to evaluate the efficacy of treating DCFW using rice straw in combination with zeolite and Moringa oleifera seeds.

2. Materials and Methods:

2.1 Dairy Cattle Farm Wastewater (DCFW) Collection and Characterization:

The DCFW used in this study was obtained from the Rami farm located in the Balenda town, Barzan, Erbil, Iraq (36.14080354670263N, 44.071224790323114E). DCFW samples were collected as grab samples from the drain present at the slaughter hall discharge point, stored in 25 L polyvinyl chloride (PVC) containers, and refrigerated at 4oC. The characteristics of the untreated DCFW used in this study are shown in Table 2.1.

2.2 Pilot-Scale Treatment Setup:

In the present research, a lab-scale treatment system for DCFW was designed, including three sequential stages:[1] a sedimentation process for the elimination of suspended solids; [2] a coagulation process using natural coagulants to reduce suspended and dissolved solids, as well as (COD) and (BOD). The natural coagulants employed included zeolites (Z) and Moringa oleifera seeds (MO). These coagulants were applied at varying concentrations and optimized through jar testing. [3] The third treatment step involved natural filtration using physically activated rice straw to further purify the effluent. The goal of this multi-stage approach was to improve overall treatment efficiency and comply with discharge standards.

2.3 Sedimentation Process:

Before the coagulation stages, a 10-liter volume of raw (DCFW) has been subjected to a 24-hour sedimentation process. This was performed by transferring the collected wastewater into a 20-liter capacity plastic container. Samples were collected both before and after the sedimentation period to investigate the impact of such pre-treatment steps on key water quality parameters, including COD, BOD, TSS, TDS, EC, TP, TN, and TOC.

2.4 Optimization of Coagulant Concentrations Using Jar Testing:

As a natural coagulant, Sigma-Aldrich provided the natural zeolite. To determine the optimal zeolite dosage, different concentrations were evaluated. Moringa oleifera seeds were procured from a local market in Erbil city. A practical method for preparing the coagulant involves removing the hulls and wings from the kernels; placing the crushed seeds in the oven dry at a temperature of 105 oC for 7 h; grading the dried seeds using a mortar and sieve within 710 sizes, and finally taking Moringa seed powder [31]. The used dosages of (Z) and (MO) are illustrated in Table 2. A standard jar test apparatus Figure 1 was used to assess the effectiveness of DCFW coagulation. 500 mL samples of homogenized DCFW were placed into beakers, and initial water quality parameters (pH, COD, BOD, TSS, TP, TN, EC, and TDS) were measured. The coagulation experiments began with a rapid mixing phase (170 rpm, 3 min) to facilitate coagulant-colloid interactions, followed by a slow flocculation phase (20 rpm, 20 min) to encourage floc formation. After that, settling took place over 1 hour. After settling, Samples were taken in triplicate from the top of each beaker's supernatant for investigation.

Figure 1. Jar test used in the coagulation and filtration of DCFW

2.5 Filtration:

Rice straw (RS), provided from a local farm, which was pre-treated by washing to get rid of contaminants, and then oven-dried at 105°C. Physical activation was achieved by a two-hour boiling in distilled water. After that, the RS was subsequently drained, dried to a consistent weight at 105°C, and safekeeping in desiccators [32]. Filtration columns were constructed using plastic funnels (20 cm height, 5 cm diameter), packed with the prepared RS to a depth of 20cm. For the filtering step, the optimum coagulant dose was chosen based on the maximal COD and BOD removal from the jar test. The filtrate was collected and analyzed for residual pollutants.

2.6 Analytical Methods:

COD was measured using the closed reflux titrimetric method [33]. BOD: determined using the 5-day BOD test [33]. TSS is measured by filtering the sample through a pre-weighed filter paper and drying at 105°C [33]. Turbidity was measured using a turbidimeter (HACH 2100N). TN and TP were analyzed using a spectrophotometer (HACH DR 6000) following standard methods [33]. All experiments were conducted in triplicate, and the results were expressed as mean ± standard deviation.

3. Results and Discussion:

3.1 Effect of sedimentation of DCFW:

Primary sedimentation is a fundamental physical treatment method that doesn't require chemical additions because it relies on gravity. Because of this, the procedure is naturally inexpensive and straightforward to run [34]. previous

Table 1. The characteristics of the untreated DCFW before and after 24 hr. of settling.

Parameters	Unit	Untreated DCFW	24 hr. settled DCFW	Removal percentage%
pH		9.46 ± 0.51	8.75 ± 0.58	-
COD	$mg.L^{-1}$	5350.00±312.25	4716.67±104.08	11.84
BOD	$mg.L^{-1}$	3449.00±107.26	2133.45 ± 102.75	38.14
TSS	$mg.L^{-1}$	4900 ± 164.58	1980.33 ± 108.17	59.59
TDS	$mg.L^{-1}$	4497 ± 81.73	4231 ± 100.50	5.92
EC	$\mu S.cm^{-1}$	7890 ± 89.66	7043 ± 92.45	10.74
TP	$mg.L^{-1}$	193.95 ± 20.60	170.35 ± 18.27	12.17
TN	$mg.L^{-1}$	598.74 ± 28.58	574.06 ± 31.27	4.12
TOC	$mg.L^{-1}$	1158.57 ± 46.34	1033.45 ± 32.11	10.80

Table 2. Coagulants and their dosage.

	Coagulant	
	Zeolite (Z)	Moringa oleifera seeds (MO)
Coagulant dosage ($g.500ml^{-1}$)	0.3	0.1
	0.4	0.2
	0.5	0.3
	0.6	0.4
	0.7	0.5

studies, such as [35], frequently used pre-settled or diluted dairy wastewater as their influent. Conversely, raw, untreated DCFW was used in this experiment, which resulted in a greater initial pollutant load. Untreated raw DCFW, which showed high concentrations of contaminants, was subjected to a 24-hour sedimentation period at room temperature before the application of coagulants. This pretreatment stage led to a significant decrease in BOD from 3449.00 ± 107.26 mg/L to 2133.45 ± 102.75 mg/L, corresponding to a 38.14% removal efficiency. This is due removal of settleable organic matter and the reduction of suspended solids. The observed BOD removal percentage in this study is approximately the same as that reported by [36]. Concurrently, COD and TSS were reduced by 11.84% and 59.59%, respectively. The highest contamination boundary limits decreased after a 24-hour primary sedimentation period. However, the subsequent investigation showed that COD, BOD, and suspended solids concentrations remained significantly high. Analysis of the effluent characteristics after the 24-hour sedimentation period showed higher levels of organic COD and BOD. Interestingly, the settled effluent's BOD/COD ratio was found to be 0.4. The wastewater is moderately biodegradable based on this ratio, which indicates that biological treatment can be achieved, but is insufficient on its own [37]. On the other hand, there was little nutrient loss throughout the 24-hour main sedimentation phase. This can be noted by the removal of TP (12.17%), TN (4.12%), and TOC (10.8%).

3.2 Effect of the Coagulation Process :

Zeolite (Z) and Moringa oleifera seed (MO) powder were applied in coagulation studies to assess the removal effectiveness of utilized coagulants in DCFW treatment. A traditional jar test apparatus was employed to investigate how various coagulant concentrations affected the effectiveness of pollution removal. Different Z and MO concentrations were used in two different sets of experiments. Comparing their removal performances and figuring out the ideal coagulant dose were the main goals of these investigations. (Z) coagulation was performed on DCFW samples at doses of 0.3, 0.4, 0.5, 0.6, and 0.7 g/500mL once they had settled for 24 hours. Increasing Z dosages correlated with increased pollutant removal efficiencies. Optimal removal was observed at 0.7 $g.500ml^{-1}$, achieving the following percentages: COD (68.90%), BOD (64.92%), TSS (39.38%), TDS (66.75%), and EC (61.95%) Figure **??**. The TN and TOC removal percentage of the sample showed the highest removal efficiency of 72.95%, 62.98% at 0.7 $g.500ml^{-1}$, respectively, while the best removal percentage for TP was 33.23% recorded at 0.6 $g.500ml^{-1}$ Figure 3.this is due to low effinity of coagulant for phosphate ions. However, beyond this concentration, the removal rate may plateau or even decline slightly due to particle aggregation, which lowers surface area, or saturation of active sites. When comparing the results with those from previous investigations [38], achieved higher removal percentages, which are marginally greater than those currently achieved using the electrocoagulation-adsorption integrated treatment process using zeolite. The optimal removal efficiencies for several wastewater characteristics using MO are shown in Figure 4 and Figure 5. The greatest removal efficiencies that were

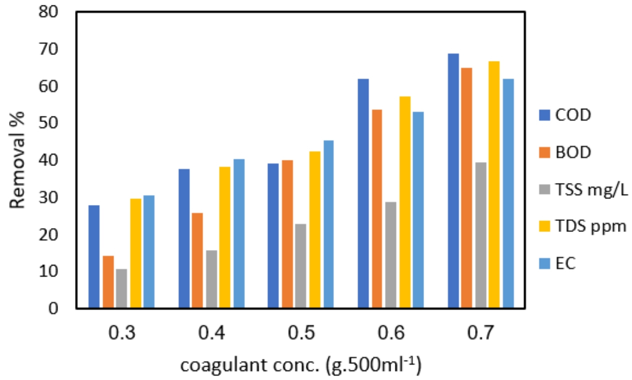

Figure 2. Removal Efficiencies of COD, BOD, TSS, TDS and EC from DCFW by Coagulation Using Zeolite.

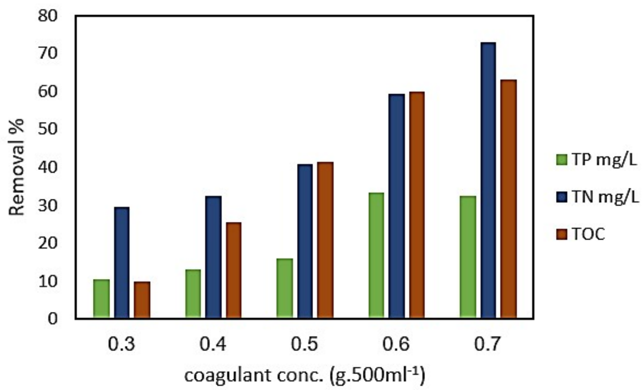

Figure 3. Removal Efficiencies of TP, TN and TOC from DCFW by Coagulation Using Zeolite.

recorded were 50.53%, 32.50%, 60.99%, 62.66%, 65.27%, 43.00% and 52.32% for COD, BOD, TDS, EC, TP, TN, and TOC. These optimal removal rates were consistently obtained at 0.5 g/500ml. However, distinct optimal MO dosages for TSS removal were 33.37% at 0.4 g.500ml^{-1}. MO demonstrated superior removal efficiency (65.27%) compared to Zeolite (33.23%) for TP, likely attributable to the reason that when MO was applied as a coagulant at a concentration of 0.5 g.500ml^{-1}. The cationic proteins found in MO seeds function as chemical coagulants, neutralizing negatively charged particles (such as phosphate ions) and facilitating them to clump together for extraction [39].

3.3 Assessment of Filtration Efficiency Using Physically Activated RS.

Coagulant concentrations of 0.7 g.500ml^{-1} for Z and 0.5 g.500ml^{-1}for MO were chosen as influents for the succeeding rice physically activated rice straw filtration process. These particular dosages represent the optimal Concentration determined in a prior experimental stage, for the highest removal efficiencies of BOD, COD, and TSS for both coagulants. Figure 6 presents data showing the observed removal

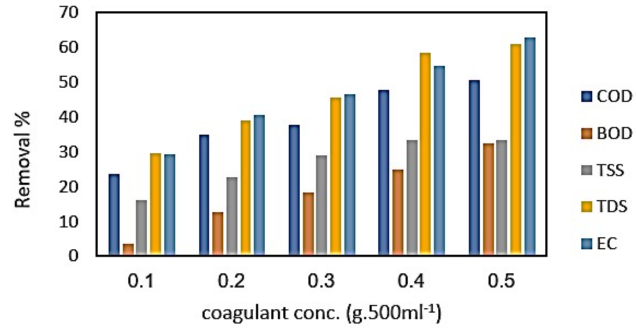

Figure 4. Removal Efficiencies of COD, BOD, TSS, TDS, and EC from DCFW by Coagulation Using MO.

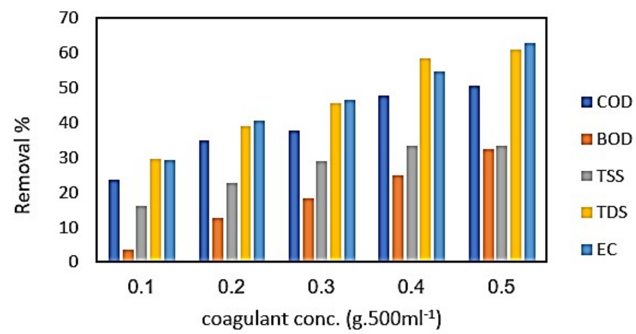

Figure 5. Removal Efficiencies of TP, TN, and TOC from DCFW by Coagulation Using MO

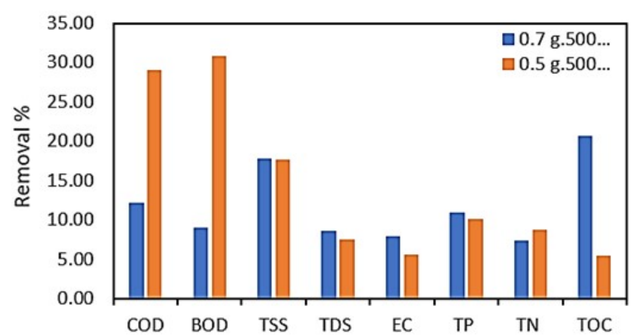

Figure 6. Rice straw filtration process removal efficiency of wastewater (0.7 g.500ml^{-1} Z and 0.5 g.500ml^{-1}MO)

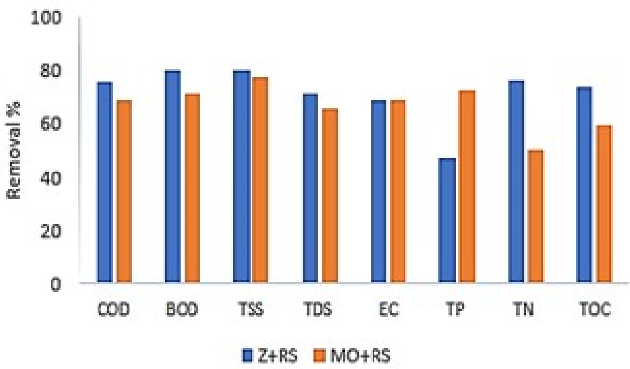

Figure 7. The removal efficiency of treated wastewater (0.7 g.500ml^{-1} Z and 0.5 g.500ml^{-1} MO)

efficiencies for various parameters achieved by the RS filtration step when Z was applied as a coagulant at a concentration of 0.7 g.500ml^{-1}. Specifically, removal efficiencies were 12.14% for COD, 9.10% for BOD, 17.79% for TSS, 8.62% for TDS, 7.43% for TN, and 10.97% for TP. RS filtration showed the highest removal for TOC with 20.76%. TOC is made up of several organic molecules. A specific larger surface area of RS provides more sites for adsorption, which allows these molecules to bind to, leading to higher removal efficiency. Physically activated process dramatically increases the specific surface area and pore volume of RS (29,40). The results illustrated in the Figures denote that the highest removal efficiencies achieved using RS were 29.06% for COD, 30.79% for BOD, TSS (17.68%), and TOC (17.72%) at a dosage of 0.5 g.500ml^{-1} of Moringa oleifera (MO). An assessment of the current DCFW treatment system, employing two different natural coagulants, was conducted by evaluating the removal percentages of the whole system's parameters (all three steps). Figure 7 summarizes these data, providing a direct comparison of the efficiencies achieved by natural coagulants and RS. Among the used coagulants, zeolite, a natural coagulant, exhibited superior removal efficiencies for COD (75.91%), BOD (80.28), TSS (79.86%), TDS (71.42%), TN (75.99%) and TOC (73.84%) when applied at a concentration of 0.7 g/500ml and filtered by RS (Table 3. Throughout all three stages of the system, the MO and RS showed notable removal of TP, achieving a removal efficiency of 72.59% at an MO concentration of 0.5 g.500ml^{-1}. This efficiency greatly surpassed that of the Z+RS system, which yielded only a 47.23% TP removal and a Z concentration of 0.7 g.500ml^{-1} within pH 7.87. Despite the pilot-scale treatment process's proven ability to significantly reduce pollutants in the DCFW treatment system, the resultant treated cattle farm wastewater (DCFW) is persistently not able to satisfy the recommended regulatory discharge requirements across all evaluated parameters. This is due to the extremely high initial pollutant load of wastewater, because if the initial concentration is very high, the "residual" concentration may still be higher than discharge limitations even if a treatment method achieves a high percentage clearance.

4. Conclusions :

The present investigation evaluated a dairy cattle farm wastewater (DCFW) integrated treatment system that involved primary pretreatment sedimentation, coagulation using natural zeolite (Z) and Moringa oleifera seeds (MO) coagulants, followed by filtration using physically activated rice straw (RS). Preliminary 24-hour sedimentation proved to be a valuable initial step, effectively reducing BOD and TSS. While showing moderate reductions in COD, TP, and TOC. However, this stage demonstrated limited efficacy in the removal of TN, with only 4.12% and 5.92% for TDS. The BOD/COD ratio of 0.4 after sedimentation showed that a large portion (60%) of the remaining organic load would need physicochemical rather than biological treatment. Coagulation played an essential role in improving pollutant removal. The coagulant and target pollutant were shown to have unique optimal doses. A Zeolite dose of 0.7 g.500ml-1 achieved the highest removal efficiencies for COD, BOD, and TSS. Although a higher Z dose of 0.7 g.500ml-1 was necessary for optimal removal of TDS, EC, TN, and TOC, while TP removal peaked at 33.23% with 0.6 g.500ml-1 Z. In the first coagulation steps, zeolite at 0.6g/500ml continuously showed better performance for physicochemical parameters. The system's total efficiency was further increased by the succeeding rice straw (RS) filtering process, which used influents that had been pre-treated with optimal coagulant concentrations. Interestingly, the RS filtering stage produced significant removal efficiency across a number of parameters when MO was utilized as the coagulant at 0.5 g.500ml-1: 29.06% for COD, 30.79% for BOD, and 17.68% for TSS. While the RS filtering stage showed a significant removal efficiency for TOC at 0.7 g.500ml-1 zeolite. A comparative assessment of the entire system's stages highlighted that the MO+RS combination achieved a significantly higher TP removal efficiency of 72.59% (at 0.5 g/100mL MO), outperforming the Z+RS system, which only achieved 47.23% TP removal. In conclusion, the results show that a multi-stage approach, combining preliminary sedimentation, optimized natural, and physically activated RS filtration, offers a viable and effective strategy for the treatment of dairy cattle farm wastewater (DCFW). The selection of the right coagulant and its dosage is essential for targeting certain pollutants, even though the RS filtration step helps considerably in overall pollutant reduction. Optimizing the integration of these phases and investigating the system's overall long-term performance and economic feasibility could be the main areas of future study.

Table 3. The characteristics of the untreated and treated DCFW (0.7 g.500ml^{-1} for Z and 0.5 g.500 ml^{-1} for MO)

Parameters	DCFW	Treated Wastewater			
		Z+RS	Removal %	MO+RS	Removal %
pH	9.46 ± 0.51	8.13 ± 0 .45	-	7.87 ± 0.35	
COD (mg.L^{-1})	5350.00 ± 312.25	1288.55 ± 143.54	75.91	1655.33 ± 105.23	69.06
BOD (mg.L^{-1})	3449.00 ± 107.26	680.25 ± 94.31	80.28	996.67 ± 77.15	71.10
TSS (mg.L^{-1})	7890 ± 89.66	986.88 ± 82.42	79.86	1086.33 ± 92.61	77.83
TDS (mg.L^{-1})	4900 ± 164.58	1285.45 ± 80.25	71.42	1526.67 ± 89.25	66.05
EC (µS.cm^{-1})	4497 ± 81.73	2466.67 ± 112.73	68.74	2480.34 ± 100.45	68.56
TP (mg.L^{-1})	4866.66 ± 124.60	102.35 ± 19.43	47.23	53.17 ± 12.32	72.59
TN (mg.L^{-1})	4789.15 ± 118.58	143.73 ± 33.62	75.99	298.71 ± 48.37	50.11
TOC (mg.L^{-1})	1158.57 ± 46.34	303.11 ± 41.22	73.84	465.42 ± 47.42	59.83

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Data Availability Statement: All of the data supporting the findings of the presented study are available from correspond ing author on request.

Declarations:
Conflict of interest: The authors declare that they have no conflict of interest.

Ethical approval: This research did not include any human subjects or animals, and as such, it was not necessary to obtain ethical approval

Author contributions: This work was carried out in collaboration between all authors. Ruya M. Ahmed contributed to the design of the study, collected samples and analyses, and wrote the paper with input from all authors. Mohammed A. Othman conceptualized and contributed to the study design and implication of the study, visited the field for sample collection, and reviewed and edited the final manuscript draft. All authors read and approved the final manuscript

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المعالجة الفعالة لمياه الصرف الصحي لمزارع الماشية: نهج مشترك باستخدام المواد المسببة للتخثر الطبيعية مع ترشيح النفايات الزراعية

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الخلاصة

في هذه الدراسة استُخدمت عملية تجريبية من ثلاث خطوات لمعالجة مياه الصرف الصحي لمزارع الأبقار الحلوب من مزرعة رامي في بلدة بليندا، برزان. بدأت العملية بالترسيب، تلتها عملية التخثر والتكتل باستخدام تراكيز مختلفة من الزيوليت الطبيعي (*Z*) وبذور المورينجا أوليفيرا (*MO*) . أما الخطوة الأخيرة فكانت الترشيح باستخدام قش الأرز المعالج فيزيائياً (*RS*) . تم تقييم كل مرحلة على حدة من خلال تحديد نسب إزالة كل ملوث تم قياسه، ثم تم تقييم العملية بأكملها باستخدام نفس الطريقة. تضمنت العوامل التي تم التحقيق فيها مؤشرات فيزيائية كيميائية أساسية مثل إجمالي المواد الصلبة العالقة (*TSS*) و إجمالي المواد الصلبة الذائبة (*TDS*) و الموصلية الكهربائية (*EC*) و *COD* و *BOD* و إجمالي النيتروجين (*TN*) و إجمالي الفوسفات (*TP*) و إجمالي المركبات العضوية (*TOC*) . كانت التركيزات المثلى لكل مادة تخثر مستخدمة 0.7 غم / 500 مل $^{-1}$ لـ *Z* و 0.5 غم / 500 مل $^{-1}$ لـ *MO* ، وفقًا لنتائج اختبار الجرة. تم الحصول على أقصى كفاءة إزالة لـ *COD* و *BOD* و *TSS* و *TDS* و *EC* و *TN* و *TOC* عند 0.7 غم / 500 مل $^{-1}$ لـ *Z* أثناء عملية التخثر. من ناحية أخرى، أظهر *MO* كفاءة إزالة محسنة لـ *TP* عند 0.5 غم / 500 مل $^{-1}$ وفقًا للنتائج ذات الصلة، تفوق *MO* على مادة التخثر الطبيعية *Z* في إزالة الفوسفور، بينما كان *Z* أكثر فعالية في القضاء على مجموعة أوسع من الملوثات العضوية وغير العضوية. أظهر تقييم شامل لنظام المعالجة بأكمله، والذي تضمن الترشيح باستخدام قش الأرز المُنشَّط فيزيائيًا (*RS*) ، أداءً مثاليًا في إزالة الرواسب عند استخدام *Z* بتركيز 0.7 غم 500 / @\ @\ مل $^{-1}$ كمادة مُخثِّرة. بلغت نسب الإزالة المُحققة 75.91 % لطلب الأكسجين الكيميائي (*COD*) ، 80.28 % لطلب الأكسجين البيولوجي (*BOD*) ، و 79.86 % للمواد الصلبة العالق (*TSS*) ، و 71.42 % للمواد الصلبة الذائبة (*TDS*) ، و 68.74 % للمركبات العضوية المتطايرة (*EC*) ، و 75.99 % للمركبات العضوية المتطايرة (*TN*) ، و 73.84 % للكربون العضوي الكلي (*TOC*) . في المقابل، حقق المزيج النوعي 0.5 غم 500 / @\ @\ مل $^{-1}$ من هيدروكسيد الصوديوم ترشيح *RS*) أعلى كفاءة لإزالة الرواسب العالقة (*TP*) بنسبة 72.59 %.

الكلمات الدالة : مياه الصرف الصحي لمزارع الأبقار؛ التخثر؛ الزيوليت؛ بذور المورينجا أوليفيرا؛ قش الأرز؛ الترشيح

التمويل: لايوجد

بيان توفر البيانات: جميع البيانات الداعمة لنتائج الدراسة المقدمة يمكن طلبها من المؤلف المسؤول

اقرارات: تضارب المصالح: يقر المؤلفون انه ليس لديهم تضارب المصالح.

الموافقة الأخلاقية: لم يتضمن البحث اى تجارب على البشر اق حيوان، باتالي لم يكن من ضرورةالحصول على موافقة اخلاقة

مساهمات المؤلفين: : تم تنفيذ هذا العمل بالتعاون بين جميع المؤلفين. ساهمت رويا م. أحمد في تصميم الدراسة، وجمعت العينات وأجرت التحليلات، وكتبت البحث بمشاركة جميع المؤلفين. قام محمد ع. عثمان بوضع الفكرة والمساهمة في تصميم الدراسة وتطبيقها، وزار الموقع لجمع العينات، وقام بمراجعة وتحرير المسودة النهائية للمخطوط. قرأ جميع المؤلفين ووافقوا على النسخة النهائية من المخطوط.