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Study The Efficiency of Using an Anaerobic Reactor Equipped with Biological Carriers with Constructed Wetlands in Wastewater Treatment

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Abstract:
Wastewater treatment technologies have spread that significantly improve environmental performance and helping maintain environmental continuity and sustainability when applied. The most important of these technologies are anaerobic biological treatment and phytoremediation, which is a form of biological treatment.
The background of the research emerges by linking two types of treatment technologies (an anaerobic reactor equipped with biological carriers as a primary treatment stage with constructed wetlands as a secondary treatment stage) as a real solution capable of treating raw wastewater at the lowest possible cost.
This research aims to evaluate the efficiency of wastewater treatment through these treatment techniques according to local conditions by implementing a pilot treatment plant by relying on reference studies and global experiences that used these techniques as a sustainable option for treatment (from technical and economic aspects). Study the effect of the design parameters for each of the two treatment stages, in the anaerobic reactor (hydraulic residence time, filling ratio of biological carriers, and type of carrier material) and in constructed wetlands (type of flow and type of plant) to reach the best treatment efficiency of this system and the environmental and economic benefits reflected on that.
The research will be conducted on the experimental treatment plant at the Faculty of Agriculture at Damascus University as a spatial area for study, and after sampling, the concentrations of pollutants (pH, COD, BOD, TSS) will be experimentally determined. Then analyze the results and link them together in order to prepare a mathematical model linking the organic load and the treatment efficiency of the proposed method, and compare these results with Syrian Standard No. 2752-2008 regarding specifications of treated wastewater for irrigation.

Key Words: Anaerobic Reactor, Biological Carriers, Constructed Wetland, Organic Load.

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دراسة كفاءة استخدام المفاعل اللاهوائي المزود بالحوامل البيولوجية مع الأراضي الرطبة الصنعية في معالجة مياه الصرف الصحي

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الملخص:

انتشرت تقانات لمعالجة مياه الصرف الصحي تحسن من الأداء البيئي بشكل ملحوظ وتساعد على الاستمرارية والاستدامة البيئية عند تطبيقها ومن أهمها المعالجة البيولوجية اللاهوائية والمعالجة النباتية التي هي شكل من أشكال المعالجة الحيوية. من هنا تبرز خلفية البحث الذي يتناول الربط بين نوعين من تقنيات المعالجة (حوض تخمير لاهوائي مزود بحوامل بيولوجية كمرحلة معالجة أولية مع الأراضي الرطبة الصنعية كمرحلة معالجة ثانوية) كحل حقيقي قادر على معالجة مياه الصرف الصحي الخام وبأقل كلفة ممكنة.

يهدف هذا البحث إلى تقييم كفاءة معالجة مياه الصرف الصحي عبر هذه التقنيات من المعالجة وفقاً للظروف المحلية من خلال تحقيق محطة معالجة تجريبية بالاعتماد على الدراسات المرجعية والتجارب العالمية التي استخدمت هذه التقنيات وكخيار مستدام للمعالجة (من النواحي الفنية والاقتصادية). ودراسة تأثير البارامترات التصميمية الخاصة بكل مرحلة من مرحلتي المعالجة، في حوض التخمير اللاهوائي (زمن المكث الهيدروليكي ونسبة ملء الحوامل البيولوجية ونوع مادة الحامل) وفي الأراضي الرطبة الصنعية (نوع الجريان ونوع النبات) للوصول إلى أفضل كفاءة معالجة لهذا النظام وما ينعكس على ذلك من فوائد بيئية واقتصادية.

سيتم إجراء البحث على محطة المعالجة التجريبية في كلية الزراعة بجامعة دمشق كحيز مكاني للدراسة، وبعد عملية أخذ العينات من المحطة يتم تحديد تراكيز الملوثات (pH, COD, BOD, TSS) تجريبياً. ومن ثم تحليل النتائج وربطها مع بعضها البعض لإعداد نموذج رياضي يربط بين الحمل العضوي الداخل وكفاءة المعالجة لطريقة المعالجة المقترحة، ومقارنة هذه النتائج مع المواصفة القياسية السورية رقم 2752–2008 الخاصة بمواصفات مياه الصرف الصحي المعالجة لأغراض الري.

الكلمات المفتاحية: حوض التخمير اللاهوائي – الحوامل البيولوجية – الأراضي الرطبة الصنعية – الحمل العضوي.

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Introduction:

Water is one of the most valuable natural resources in the world, and as a result of the population, urban and industrial development that the world is witnessing, natural sources of water are depleted at a large rate that affects the quantity and quality of water, as well as the exposure of these natural sources to pollution continuously.

Wastewater, with its organic waste (organic content is the main factor in wastewater pollution), impurities and chemicals (such as soap and industrial detergents), some types of harmful bacteria, in addition to toxic heavy metals and hydrocarbons, is one of the largest pollutants of natural water sources, as it is often discharged directly and without any appropriate treatment to natural sources of water, so wastewater treatment is an urgent necessity nowadays.

The search problem:

identify the main problem of research on the Through contact with reality, it is possible to and the spread of many random estuaries, especially in small ،problem of untreated sewage communities scattered throughout rural and dry areas in Syria, because of their bad effects on of artificial wetlands treatment plants requires large areas, which leads the environment. The use to an increase in the cost of construction and operation, with the possibility of clogging the atment treatment filter over time as a result of the accumulation of organic matter in the tre basins when the initial treatment before the artificial wetlands basins is insufficient, and this has limited the use of this effective method in wastewater treatment.

of research Importance:

- treatment by anaerobic methods has Over the past thirty years, the process of wastewater become more popular due to its many advantages in terms of reduced space, nutrient and energy requirements, the production of less protectors as well as the production of biogas as a renewable energy source.
- of biological carriers (cellulosic agricultural residues) to the anaerobic biological The addition reactor supports the treatment system, as agricultural residues are characterized by their high treatment; due to the ability to adsorb and their use as adsorbents is promising for wastewater abundance of these materials and their renewable potential. The choice of walnut and almond shells also has several advantages, as these shells are considered to have a porous structure, shape that causes rapid attachment and the their cost is low, they have a stable geometric development of bacterial populations.

▪ Artificial wetlands treatment plants are easy to set up, operate and maintain, do not need a staff to being or supervisors and can be monitored and managed by one person, in addition environmentally friendly as they do not produce any undesirable effects.

Research objective:

This research aims to evaluate the efficiency of wastewater treatment via anaerobic reactor ding to local conditions and selected equipped with biological stands and artificial wetlands, accor Through .design parameters:

- To study the effect of the hydraulic condensate time, the filling ratio of biological carriers and the reactor type of biological carrier material on the processing efficiency in an anaerobic.
- Study the influence of the type of runoff and the type of plant used on the efficiency of treatment in artificial wetlands.

Literature Review:

There are many previous studies that dealt with the subject of wastewater treatment through the anaerobic reactor and artificial wetlands and dealt with it from different sides, we will review a number of studies that have been benefited from with reference to their most prominent features. These studies varied between Arabic and foreign in the period between 2003 and 2022, which indicates their temporal and geographical diversity.
The reference studies were classified into three main axes:

The first axis: Reference Studies Using Anaerobic Reactor in Wastewater Treatment:

• A reference study in Iran in 2012, entitled: ((Laboratory-scale study to improve dwell time and organic load rate in UASB reactor for pre-treatment of wastewater at different operating temperatures)) [2]

A group of researchers studied the effect of temperature (17,20,25,30,38) and dwell time (HRT=3, 6, 9, 12 hour) on the performance of a UASB domestic wastewater treatment reactor in Lahore, Pakistan. The reactor is made of Perspex and consists of a tubular section at the bottom and a conical section at the top (GLSS) for gas collection. The tubular section was a column 120cm high, 7cm in diameter, and 5l in size. The conical section was 40cm high and 10l in size.

Processing Efficiency:

The results of the study showed that the treatment efficiency was low at 17 degrees, due to insufficient concentrations of stable solids and biomass, which consequently reduced the methanogen activity of sludge microorganisms and slowed the rate of hydrolysis. It increased with the increase in temperature, as the removal rate of (COD) and (BOD) in the reactor reached 81% and 83%, respectively at a temperature of 38, and the removal rate of (COD) and (BOD) in the reactor was 70% and 72%, respectively, at a temperature of 20 degrees and a time of stay 3hour, and increased when the stay time increased to 12hour when there is sufficient contact between sludge and wastewater, reaching 84% and 86%, respectively.
The results of the study showed that the best treatment efficiency was at the 4hour dwelling time, and therefore the efficiency gradually decreased with the increase in the length of stay. The optimal range for organic loading OLR was between (7.2-10.8 kg/m3.day) in all temperature conditions, with the reactor's COD removal efficiency of 85% at 30°C and 73% at 20°C.

• A reference study in Iran in 2012, entitled: ((Laboratory-scale study to improve dwell time and organic load rate in UASB reactor for pre-treatment of wastewater at different operating temperatures))[2]

A group of researchers studied the effect of temperature (20.30) and dwell times (3,4,5,6hour) on the performance of a UASB wastewater treatment reactor in Tehran, Iran. The organic loads reached (3.6,7.2,10.8,14.4 kg/m3.day). The reactor was laboratory equipped with Plexiglas and the total volume was 5L. The study was conducted for 7 months, with the first 55 days being considered as the "start-up period". 36 samples were collected and analyzed during the study period.

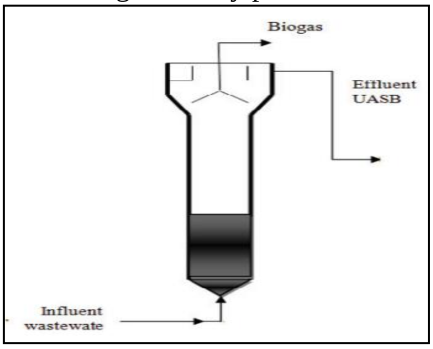


Figure (1): UASB anaerobic biological reactor [2].

Processing efficiency:

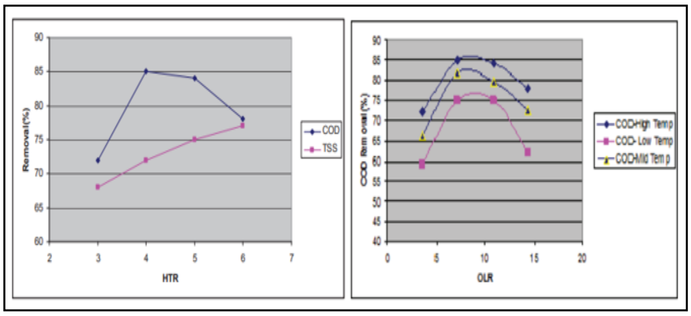
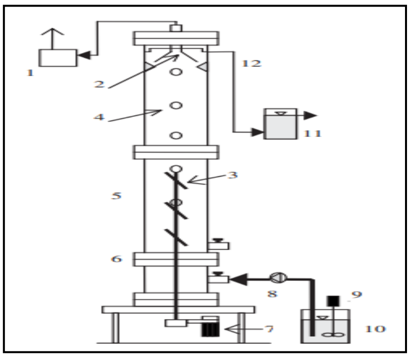


Figure (2): Removal curves for COD according to dwell time and organic loading rate [2].

The results of the study showed that the best treatment efficiency was at the 4hour dwelling time, and therefore the efficiency gradually decreased with the increase in the length of stay. The optimal range for organic loading OLR was between (7.2-10.8 kg/m3.day) in all temperature conditions, with the reactor's COD removal efficiency of 85% at 30°C and 73% at 20°C.

•in 2003, entitled: ((The effect of temperature on the A reference study in Mexico performance and microbiological aspects of uasb reactors UASB treating municipal [3]((wastewater

A group of researchers evaluated the performance of the UASB reactor in municipal wastewater treatment in North American climates at temperatures (6,11,15,20,32) and stay times (3-6hour). Where two reactors were used (each size 8L) with a height of 1m and an inner diameter of 10cm, the study period was about 900 days. The start-up process lasted for approximately 60 days with a COD removal efficiency of 70% at the end of the startup period.



uasb anaerobic biological :)3(Figure Reactor [3].

Processing efficiency:

at a The results of the study showed that the optimal treatment in terms of removal efficiency was temperature of 11 degrees Celsius andHRT for 6 Hour where the removal efficiency ،of COD and BOD respectively, was ،86% and 88%.

The Matrix of the first axis of reference studies :)1(Table

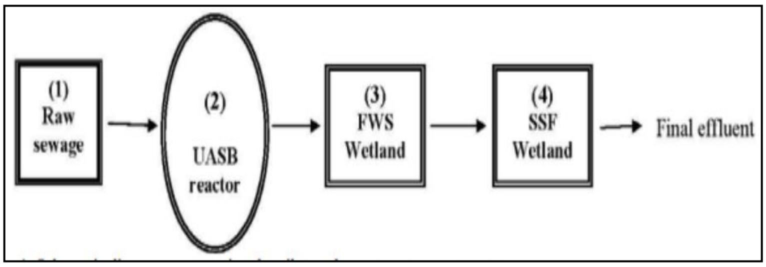
Reference	V (L)	T (C)	HRT (hour)	Removal (%)	
				COD	BOD
Mexico 2003	8	6,11,15,20,32	3,6	86	88
Iran 2012	5	20,30	3,4,5,6	85	-
Pakistan 2014	15	17,20,25,30,38	3,6,9,12	84	86

We conclude from these studies that the anaerobic reactor is able to reduce the organic load at high rates, and therefore its use as a pretreatment for artificial wetlands in this research avoids the entry and accumulation of large quantities of suspended solids on the filter medium, which prevents blockages, and prolongs the life of wetlands.

The second axis: anaerobic reactor with artificial wetlands theused reference studies that in wastewater treatment:

• A reference study in Egypt in 2009, entitled: ((Use of artificial wetlands as a post-treatment stage of anaerobic treated wastewater)) [4]

The study was conducted by a group of researchers in Egypt, where a UASB reactor with a volume of 1.3m3 with a stay time of 8hour was used, the reactor was continuously fed with municipal sewage during the study period for 6 months. Two artificial wetlands were used with two types of flow (FWS, SSF) respectively, with an area of 2.4 m2 each with a time of stay of 3day, and the two basins were planted with the plant Typha latifolia common in Egypt.



anaerobic biological :)4(Figure reactor UASB and artificial wetlands FWS,SSF [4].

Processing efficiency:

The results of the study showed that the average removal values of (TSS, BOD, COD) in the reactor amounted to (67%, 70%, and 69%) respectively. In artificial wetlands, it was (95%, 90%, and 85%) respectively. Hence, the integrated treatment system is a promising technology for wastewater treatment and use for irrigation. Anaerobic digesters reduce biological oxygen demand before it enters the two wetland units by 40-50%, so the area required for wetlands to treat wastewater in UASB digesters will be reduced by 40%, which is less than that required to treat raw wastewater.

• A reference study in Mexico in 2015, entitled: ((The effect of hydraulic retention time on the performance of an environmental wastewater treatment system consisting of an anaerobic reactor and artificial wetland) [5]

This study was conducted in order to protect Lake Chapala in Mexico from the amounts of sewage discharged by small communities in the vicinity of the lake. Using an anaerobic reactor (UASF), with dimensions of 24 * 2.3 m and a height of 1.75 m. Horizontal subsurface runoff wetlands (HSSCW), with dimensions of 7.6 x 9.2 m2 and depth of 0.6 m, Tezontle volcanic rock treatment filter which is highly porous and abundant in Mexico. Two species of ornamental plants were cultivated, Canna hybrids and Strelitzia Reginae.

The monitoring was performed for 66 weeks, divided into three periods, to test the following hydraulic retention times: HRT1 which corresbasins to 18hour in UASF and 2day in HSSCW, HRT2 corresbasins to 28hour in UASF and 3day in HSSKW, and HRT3 corresbasins to 48hour in UASF and 4day in HSSCW.

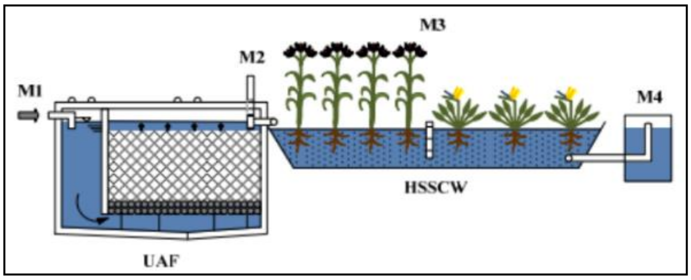


Figure (5): UAF anaerobic bioreactor and HSSCW synthetic wetlands [5].

Processing efficiency:

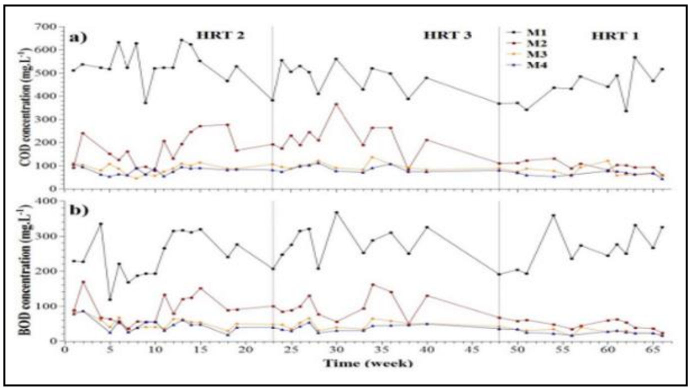


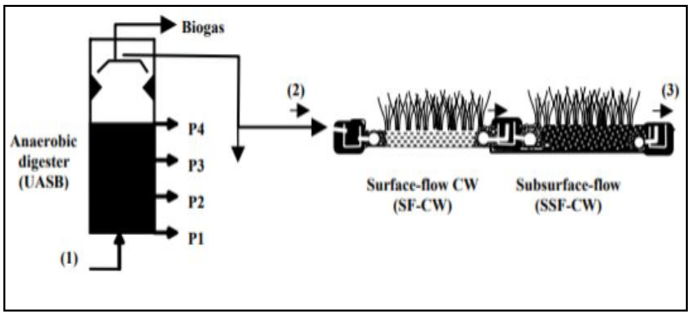
Figure (6): Removal curves for (COD, BOD) according to the dwell time [5].

The results of the study showed that the anaerobic reactor was responsible for removing most of the organic matter (50-60%). The lowest COD/BOD ratio at the M2 sampling point was 0.498, and the entire treatment system reached BOD removal (86%, 79%, 89%) for (HRT1, HRT2, HRT3) respectively. COD removal values obtained were (81%, 84%, 86%) for (HRT1, HRT2, HRT3) respectively.

•udy in Spain in 2014, entitled: ((municipal wastewater treatment in an A reference st

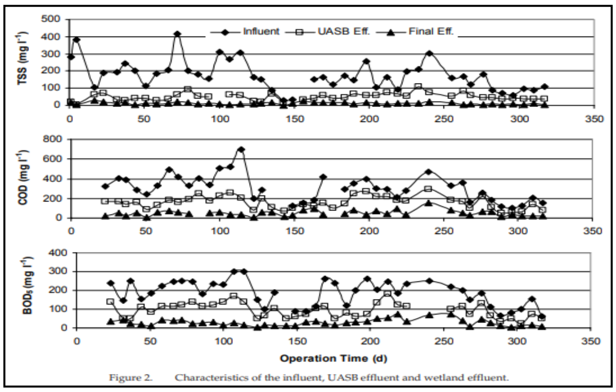
[6] ((artificial wetland system with anaerobic reactor

The wastewater treatment efficiency of the city of Santiago, Spain, has been studied. Through an experimental treatment plant consisting of an anaerobic reactor (UASB) with a size of 25.5 m3 and two wetlands with two types of flow (surface – horizontal subsurface) with an area of 25 m2 each and a depth of 0.5 m, the treatment filter is gravel with a grain gradient of 6-8 mm, planted with papyrus. The dwell time was (8-14hour), and the organic loading rate was (OLR=0.3-1.1 gCOD/l.day).



uasb anaerobic biological :)7(Figure reactor and artificial wetlands SFCW,SSFCW [6].

Processing efficiency:



for removal curves :)8(Figure (COD,TSS,BOD)depending on the time of stay [6].

Treatment efficiency in the UASB reactor: In the first months of operation (July-September) the temperature reached the highest values (18-22) and the removal of (BOD, COD, TSS) was also the highest in the operating period at 78%, 58% and 54% respectively. In the next five months (October-February) temperatures dropped (12-14) and the impacting concentrations were also lower. The lowest removal efficiency was 49%, 26% and 28% for BOD, COD, TSS, respectively.

Treatment efficiency in wetlands: Performance was stable, with COD removal efficiency (64%), TSS (75%) and BOD within (68%). Processing efficiency for the entire system: The removal efficiencies of (BOD, COD, TSS) of the entire treatment system were in the range of 90%, 78% and 74% respectively. We conclude from this study that a treatment system based on anaerobic digestion and artificial wetlands is capable of producing final treated water of quality that can meet the standards required for water bodies. Furthermore, the use of the UASB reactor as a pretreatment avoids the ingress and accumulation of large amounts of suspended solids on the filter medium and thus prevents blockages, extending the life of wetlands. This treatment system can also be used especially in rural areas and small urban areas because of its simplicity and low costs.

The Matrix of the second axis of reference studies :)2(Table.

Reference	Anaerobic Reactor		Constructed Wetland		Removal (%)	
	Type	HRT (h)	Type Flux	Plant	COD	BOD
Egypt 2009	UASB	8	FWS+SSF	Typha	85	90
Spain 2014	UASB	8,14	FWS+HSF	Bulrushe	74	78
Mexico 2015	UAF	18,28,48	HSF	Canna	86	89

We conclude from these studies that a treatment system based on anaerobic digestion and artificial wetlands is capable of producing final treated water of quality that can meet the required standards for treated water. Moreover, this system of processing can be used especially in rural and small urban areas because of its simplicity and low costs.

The third axis:

anaerobic reactor equipped with biological carriers in anused reference studies that

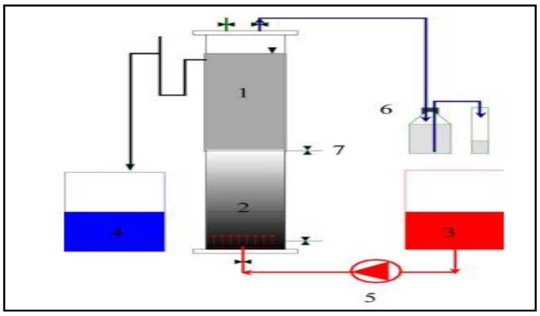
wastewater treatment:

- **of nylon A reference study in Thailand in 2003, entitled: ((Study of the effect of the use**

fibers as supporting media in anaerobic reactors on system performance and microbial

[7] ((distribution

A group of researchers investigated the contribution of nylon fibers as biological carriers in the anaerobic reactor in reducing organic matter from wastewater, and the effect of the quantity (density) of the carrier in the reactor (11,22,33kg/m3) and the dwell time (3,4,5day) in the reactors (R1,R2,R3) on the treatment yield was studied.



anaerobic biological reactors :)9(Figure (R1,R2,R3) [7].

Processing efficiency:

The results of the study showed that COD removal efficiency was more favorable in R3 (87%) and R2 (84%) compared to R1 (70%). Total biomass in reactors with greater nylon fiber densities (R2,R3) also increased, increasing from (20.4g VSS) to (67.3g VSS) in R3 and (57.5g VSS) in R2, respectively. When dwell time was reduced to 3day, COD removal efficiency decreased to 74% in R3 and 61% in R2.

- **A reference study in Syria in 2020, entitled: ((Efficiency of the work of almond peels as biological carriers in activated sludge ventilation basins)) [8]**

The researchers verified the efficiency of the work of almond peels as biological carriers, where the peels were placed at 7% of the volume of the basin for 4 months, with a change in the hydraulic dwell time (4,5,6hour) and the concentration of suspended biomass (MLSS=500,1000,2000,3000mg/l).

the reactor almond shells a month after they were placed in :)10(Figure [8].

Processing efficiency:

The results showed that the best removal efficiency of (TSS, COD) was at (HRT=5hour, MLSS=2000mg/l) and reached (92%, 90%) respectively.

• A reference study in Egypt in 2022, entitled: ((A comparative study of the performance of the UASB reactor in wastewater treatment through the use of polyethylene media and loofah sponge as biological carriers)) [9]

The researchers conducted this study to treat wastewater with a flow rate of 9.67L/day, a dwell time of 8.5hour, and a temperature of (15-20) degrees Celsius.

polyethylene media and a loofah sponge :)11(Figure [9].

Processing efficiency:

The results showed that the COD removal efficiency at 20°C reached 90% using PE polyethylene media. While it reached 95% using a loofah sponge, the results also showed a decrease in COD removal efficiency for carriers at low temperatures (15 °C) due to low microorganism activity.

of reference studies The Matrix of the third axis :)3(Table.

Reference	Anaerobic Reactor		Biological Carriers		(%)
	Type	V (L)	Type	HRT (h)	COD
Thailand 2003	UASB	6	Nylon Fiber	72,96,120	87
Syria 2020	Activated Sludge Tanks	10	Almond Shell	4,5,6	92
Egypt 2022	UASB	5	PE, Luffa Spong	8	95

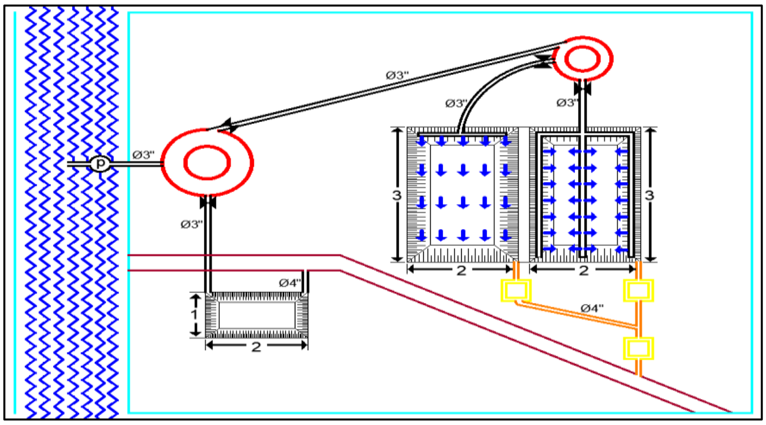
We conclude from these studies that the aforementioned carriers (nylon fibers, polyethylene media, loofah sponge) are expensive and not readily available, as they are prepared industrially in addition to many problems in transporting and storing these carriers in developing countries, which will eventually lead to increased operational costs of the processing system. Almond peels are a natural biological carrier and have given good results as they have been used in the activated sludge treatment system combined with the fixing membrane.

In this regard, the current study focuses on the use of almond shells in addition to walnut shells as natural biological carriers by the method of proven growth only, and Syria is one of the most producing countries for walnuts and almonds FAO, 2017.

Materials and methods:

which consists in choosing the research limits and ،theoretical studyincludes the **The first stage** as the reference then collecting all the information about the current status of the station as well research plan studies and preparing the

-the experimental treatment plant at the study will be conducted on :**Limitations of the research** pollution, the Faculty of Agriculture of Damascus University to treat raw sewage and reduce erobic reactor with cellulosic agricultural according to the treatment system consisting of an ana waste as natural biological carriers as a primary treatmentstage, and artificial wetlands as a secondary treatment stage. The following figure shows the horizontal projection of the Experimental Station:



horizontal projection of the experimental treatment plant :)12(Figure.

Which consists of two stages:

- ✓ Phase I: Primary treatment includes collection and sedimentation tank.
- ✓ Phase II: Secondary treatment involving two artificial wetland treatment basins tied in parallel.

The current research plan needs a pilot station with two artificial wetlands basins as a secondary treatment stage, which were designed according to the design parameters contained in the German Code according ATV-DVWK-262[10], which were adopted in the calculation of wetlands:

- ✓ On the hydraulic load given in the code ≥ 6l/m2.min
- ✓ Time duration between two consecutive loads ≥ 2-6hour

Based on these parameters, an area of 6m2 was selected for each of the two treatment basins.

includes a practical experimental study, which consists in **The second stage**:

1 −Anaerobic biological fermentation basin design:

Calculate the volume of the basin: There are two situations for calculating the volume of the pelvis:

✓ If the concentration is (COD<2.5kg/m3), the volume is calculated from the relationship:
V=HRT/24*Q

V: reactor volume (m^3).

HRT: reactor dwell time (hour).

Q: Raw water flow (m^3/d).

✓ If the concentration is (COD>2.5kg/m3), the volume is calculated from the relationship:
V=COD*Q/OLR

V: reactor volume (m^3).

COD: difference between COD concentration of water entering and leaving the reactor (kg/m^3).

Q: Raw water flow (m^3/d).

OLR: organic loading rate (kgCOD/m^3*d).

<u>Calculation of aquarium dimensions</u>**:**

✓ Calculates the area of the pelvic section of the relationship:

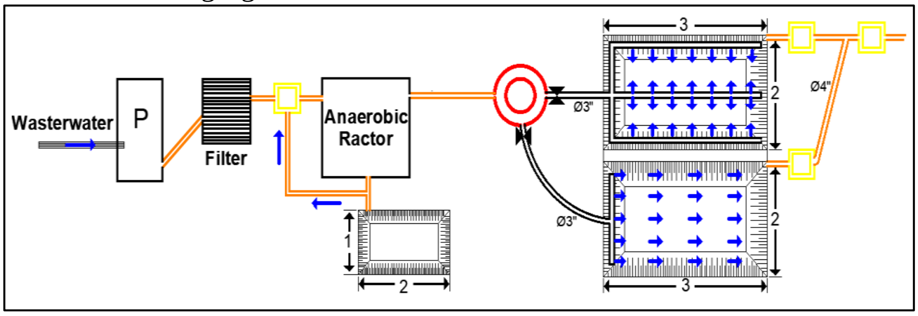
A=Q/24*v

A: reactor cross-sectional area (m^2).

Q: Raw water flow (m^3/d).

v: vertical flow velocity in the reactor (m/h).

2- Equipping the anaerobic fermentation pool with all the equipment attached to it and placing it in the station, as shown in the following figure:



horizontal projection of the experimental treatment plant :)13(Figure (anaerobic fermentation Basin, artificial wetlands).

3- Study the effect of hydraulic dwell time, filling ratio of biological carriers and type of biological carrier material on the processing efficiency in anaerobic fermenter:
Biological carriers: As early as 1838, Anselme Payen proved that the fibrous component of all plant cells has a unique chemical structure, called cellulose n(C6H10O5), is abundant in the biosphere more than any other substance, and has a high ability to absorb water due to the interaction between OH electrolytes and water molecules, but it does not dissolve in water due to the formation of strong crystal clusters due to hydrogen bonding [11].

Agricultural residues consist of extracts, fats, proteins, simple sugars, starches, water, hydrocarbons and ash. Agricultural residues are characterized by their high adsorption capacity and their use as adsorbent is promising in the future for wastewater treatment due to the abundance of these materials and their renewability [21].

Based on the interest in environmentally friendly materials for wastewater treatment, the research directed to the use of cellulosic agricultural residues as natural biological carriers, where almond and walnut shells were selected, these peels are characterized by a porous structure, low cost, and have a fixed geometric shape that causes rapid attachment and the development of bacterial communities.[8]

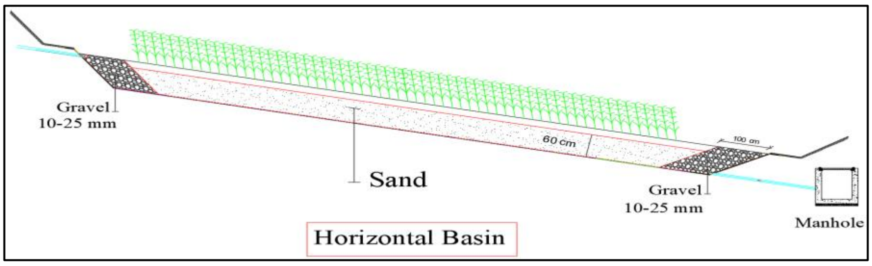
Add stands: The almond and walnut shells are dried in the oven until there is no moisture, then the dried peels are placed in sieves distributed at heights and at a specific percentage of the volume of the fermenter throughout the research period.[8]

4- Studying the effect of the type of runoff and the type of plant used on the efficiency of treatment in artificial wetlands:

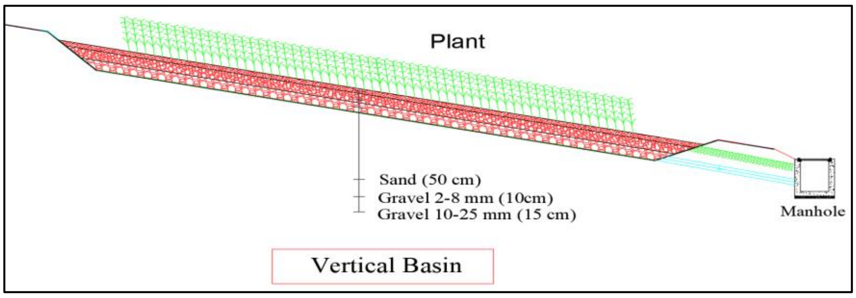
Type of flow:

two treatment basins with artificial wetlands :)14(Figure (HSF,FSF).

The first basin with horizontal subsurface flow is formed from inclined earthen shoulders with dimensions of 3 * 2 m2 and a depth of 0.5 m, and the second basin with vertical subsurface flow is formed from inclined earthen shoulders with dimensions of 3 * 2 m2 and a depth of 0.8 m, and a slope of 1% within wet basins as shown in the German standard ATV-DVWK-262.



basin with horizontal subsurface runoff :)15(Figure.



basin with vertical subsurface runoff :)16(Figure.

The treatment filter in the horizontal basin is carried out from the lenticular at a distance of 50cm at the entrance and exit of the basin with a grain gradient (10-25mm), and mazar sand at a distance of 2m at the middle of the basin with a grain gradient up to (0.4mm). In the vertical basin, the treatment filter was carried out in three layers in a row from the bottom to the top, starting with a layer of lenticular with a thickness of 15 cm and a gradient (10-25mm), then a layer of mazar sand with a thickness of 50 cm and a gradient of gradients up to (0.4 mm), and finally a layer of lenticular with a thickness of 15 cm and a gradient of gradients (10-25mm).

Manholes after plant ponds: made of plastic with a capacity of 0.02 m3, through which the leachate water from the two cane basins is diverted to the final collection channel of liquefied treated water by opening the dams within them. This is done by securing a level difference of 2% and through pipes made of PVC.

the inspection room of the Experimental Station :)17(Figure.

Final collection channel: An open concrete channel whose task is to receive and collect treated water coming from the two plant basins to be invested according to the field required for its use.

Plant Type: Two types of plants will be approved during the study period:

✓ The first plant is the cane plant that suits the climatic conditions of our country, and is also considered the traditional plant used in artificial wetlands.

Reed plant :)18(Figure.

✓ The second plant is the ornamental plant (bougainvillea) which prefers to grow in temperate climates as it suits the climate of our country.

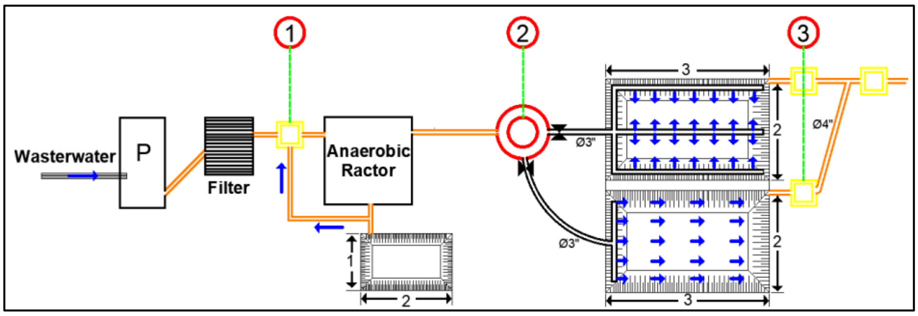
bougainvillea(ornamental plant :)19(Figure.

Sampling plan:

Before determining the place of sampling from the Experimental Station, it is necessary to mention concentrations are to be determined, or the parameters whose the pollutants whose concentrations are to be determined experimentally. The parameters are: (PH, COD, BOD, TSS).

The places for sampling are:

- ✓ From the raw sewage tank.
- ✓ anaerobic fermentation From the main distribution tank after.
- ✓ From the two manholes after the two basins are artificial wetlands .



sampling places of the experimental processing plant :)20(Figure.

the includes analyzing the results, linking them with each other, arriving at The third stage necessary recommendations and proposals, where the research results and developing the following will be followed:

1 .Analyze the results and evaluate the efficiency of treatment using cellulosic agricultural residues as biological carriers in the anaerobic reactor, and determine the treatment efficiency in the reactor according to the selected operational parameters (dwell time, type of biological carrier material, biological carrier filling ratio).

2. Analyze the results and determine the treatment efficiency after wetlands basins according to the selected operational parameters in wetlands (subsurface runoff types, plant type).

3. Finding a mathematical relationship between the treatment efficiency of the reactor and the area required for the construction of artificial wetlands.

4. Develop a mathematical model linking the incoming organic load and the processing efficiency of the reactor and wetlands together, according to local conditions and the proposed research plan.

5. Feasibility study of the proposed treatment method, and compare the results with the Syrian Standard No. 2752-2008 for the specifications of treated wastewater for irrigation purposes.

6. Recommendations and suggestions: It includes technical, hydraulic and economic justifications for the selection of filling material (walnut and almond shells), the optimal filling ratio in the anaerobic reactor and the improvements required to be followed up in subsequent research to be able to use them in this system of treatment, as well as the types of local ornamental plants and their comparison with the cane plant to study the possibility of producing other types of plants to improve aesthetic views at the estuaries of sewage and artificial wetlands or for small treatment plants for vital facilities and turn them into a civilized landscape.

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