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REMOVAL EFFICIENCY OF COD, BOD, OIL AND GREASE AND TSS FROM INDUSTRIAL WASTEWATER BY USINGELECTRO-COAGULATION

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ABSTRACT

The wastewater treatment becomes more necessity. A cheap and more effectively methods for treating liquid waste before discharging it into any other water systems is required. A lot of wastewater technologies are known which include physicochemical treatment processes and biological treatment processes .This technique depend on electrochemical technology which being improved and developed to minimize the addition of chemicals. This study was aiming to investigate the efficiency of the electro-coagulation technique for removal of COD, BOD, Oil and Grease and TSS from Industrial Wastewater from Meat and Slaughterhouse industry in Tanta, Gharbeya, Egypt. Electro-coagulation is depend on passing of an electrical current (DC current) through a liquid, using an anode electrode and cathode electrode. In present study mixed electrodes of iron and aluminum are used and under the optimum condition of current density = 20 mA/cm2, distance between electrodes = 5 cm and retention time = 40 min. It maximum removals efficiency of COD, BOD, TSS, and oil & grease were 96.6%, 96%, 94.5%, 98.1% respectively.

Keywords: Biochemical oxygen demand; electro-coagulation; iron and aluminum electrodes, chemical oxygen demand.

1. INTRODUCTION

Electro-coagulation is one of alternative technologies for many types of wastewater besides the other conventional technologies. Electro coagulation technique has advantages more than other conventional technologies as chemical coagulation, adsorption and no harmful byproducts are produced. A lot of studies reported the high efficiency of electrocoagulation for treating domestic and industrial wastewater [1,2,3].

The advantages of using electrochemical treatment for waste water are low operation, maintenance cost and its high efficiency for removing the different pollutants [4, 5].

In comparison to the conventional treatment methods the electrocoagulation-flotation treatment has greater ability to remove the COD and TSS from the industrial and domestic waste water [6, 7].

After finishing the studies which identifying the alternatives, electrocoagulation is one of the best technologies for treating the wastewater. Also reusing after treating of wastewater becomes necessary, so it is very important to develop more effective and low cost techniques for treatment of wastewater. In most of electrochemical process, current density is the most important parameter affecting on the performance of the process, it determine the production rate of the coagulant, bubble production rate, size and growth of the flocs [7, 8].

Mechanisms of removal of the electrocoagulation process include coagulation, adsorption, precipitation and floatation. Also, the effect of the DC current field on COD and TSS in aerobic mixed sludge process was investigated for determining the optimum condition for the operation [9].

Electro coagulation considers being one of the important applications of electrochemical technologies for the treatment of domestic or

industrial wastewater. Electrocoagulation has more complexes mechanisms that involving many of physical and chemical phenomena using consumable iron or aluminum electrodes to produce ions into the water stream. During the late nineteenth century, electrocoagulation was applied in wide-scale for water treatment plants in London[10], while electrolytic sludge treatment plants were operated as early as 1911 in various parts of the United States [11, 12].

The destabilization mechanism of the contaminants, particulate suspension, and breaking of emulsions taking place in an EC reactor may be summarized as follows:

- Charge neutralization of the ionic species present in wastewater by counter ions produced by the electrochemical dissolution of the sacrificial anode. These counter ions reduce the electrostatic inter-particle repulsion to the extent that the van der Waals attraction predominates, thus causing coagulation.
- Floc formation: the floc formed as a result of coagulation creates a sludge blanket that entraps and bridges colloidal particles that are still remaining in the aqueous medium [13].

Fine oxygen bubbles are generated at anode at the same time hydrogen bubbles generated at the cathode which attached to the flocs of suspended solids and making them float to the top of the surface. Also, the following physiochemical reactions occur in the Electrocoagulation cell [14, 15]:

- Electrophoretic migration of the ions in solution.
- Cathodic reduction of impurities present in wastewater.
- Reduction of metal ions at the cathode; and other complex electrochemical reactions.

Anode reaction:

$$Fe_{(s)} \rightarrow Fe^{2+}{}_{(aq.)} + 2e$$

$$Fe^{2+}{}_{(aq)} + 2\ OH^-{}_{(aq.)} \rightarrow Fe(OH)_{2(s)}$$

Cathode reaction:

$$2\ H_2O\ (l) + 2e \rightarrow H2\ (g) + 2\ OH^-{}_{(aq.)}$$

$$Fe^{2+}\ (aq.) + 2\ OH^-\ (aq.) \rightarrow Fe\ (OH)_{2(s)}$$

Overall reaction

$$Fe_{(s)} + 2\ H_2O_{(l)} \rightarrow Fe\ (OH)_{2(s)} + H_{2\ (g)}$$

The iron hydroxide which formed from the reaction of the anode will be in aqueous form as gelatin suspension which called flocs which remove the wastewater pollutants by electrostatic attraction then coagulation.

The $H_{2\ (g)}$ which formed from redox reaction will remove the dissolved organics or suspended particles by flotation [11, 12].

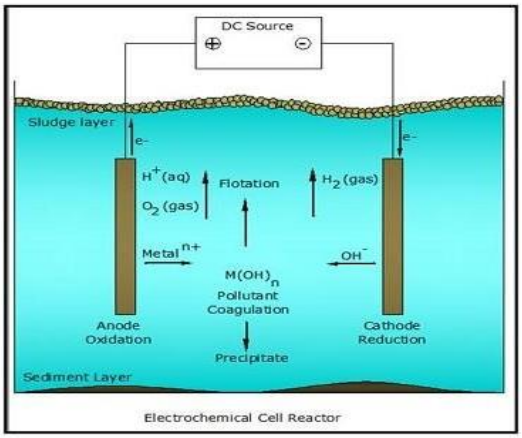

Fig. 1.Electrochemical Cell [8]

2 MATERIAL AND METHODS

2.1 sampling

Industrial Wastewater samples are taken from the effluent of meat and slaughterhouse industry in Tanta in the period from July 2018 to December 2018.

2.2 Experimental setup

In this study Lab-scale (batch process), which consisting of an electrolysis cell, a magnetic stirrer, a power supply, a pH meter, Conductivimeter and Turbidimeter. The electrolysis cell made of glass 20 Cm in width, 25 Cm in length, and 30Cm in height and two iron and two aluminum electrodes are connected to the DC power supply. Dimensions of the electrodes were 1 mm in thick, 100 mm in width and 250 mm in height. Distances between electrodes are at 5 Cm. every run about 5000 ml of total volume sample putted in the reactor. The iron and aluminum electrodes were connected to the DC power supply from 0

to 6 amps. And stirrer used for 30 rpm for mixing.

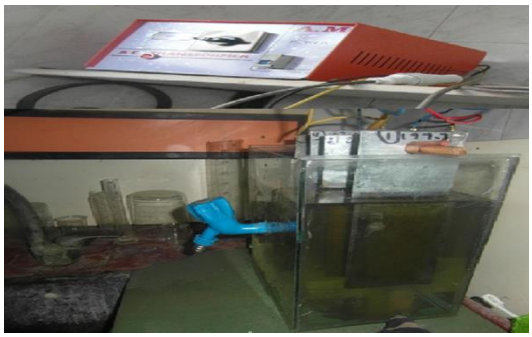

Fig. 2.Electrochemical Cell

2.3 Experimental method

Table (1) shows the optimum conditions for third case study from Meat and Slaughterhouse industry in Tanta.

Ser.	Parameter	
1	Electrode type	Mixed electrode of Aluminum and Iron.
2	Flow rate	Batch process
3	Current density	20 mA/cm2
4	Distance between electrodes	5 cm
5	Reverse polarity	Yes every 10 min.
6	EC Time	40 min

3. RESULTS AND DISCUSSION

In this study the effluent of treated industrial waste water is place in the batch unit with mixed electrodes of iron and aluminum resulting in producing ferrous Fe^{2+} and aluminum Al^{3+}ions during the electrocoagulation process. Total suspended solids TSS removal efficiency was 89 %, Biochemical oxygen demand was 86 % turbidity was 90 % and oil and grease was 99 % by using mixed electrodes of iron and aluminum for treating slaughterhouse wastewater [13].

3.1 Meat and Slaughterhouse industry in Tanta

3.1.1 Temperature

The temperature in samples of Meat and Slaughterhouse waste water during from July 2018 to December 2018 was ranged between 26 and 34 ºC. This is normal for industrial wastewater which increase in summer and decrease in winter.

Table (2) Show the results for raw, treated waste water and removal efficiency for samples collected from Meat and Slaughterhouse industry in Tanta.

item			2018					
			July	August	Sept.	Oct.	Nov.	Dec.
Temp.	ºC	Raw	32	33	29	31	29	26
		Treated	33	34	31	33	30	28
pH	-	Raw	6.8	7.2	7.1	6.8	7.1	6.3
		Treated	7.1	7.4	7.5	7.2	7.4	6.8
TSS	mg/L	Raw	732	689	868	545	663	798
		Treated	23	50	38	29	48	42
		Removal efficiency	96.9%	92.7%	95.6%	94.7%	92.8%	94.7%
TDS		Raw	640	880	860	920	620	850
		Treated	620	840	855	900	596	820
BOD		Raw	989	845	912	1012	802	1054
		Treated	32	27	55	41	35	61
		Removal efficiency	96.8%	96.8%	94.0%	95.9%	95.6%	94.2%
COD		Raw	1560	1345	1489	1621	1210	1870
		Treated	66	29	78	34	47	56
		Removal efficiency	95.8%	97.8%	94.8%	97.9%	96.1%	97.0%
Oil and Grease		Raw	251	145	223	186	123	137
		Treated	5.4	3.2	6.2	1.4	1.8	2.1
		Removal efficiency	97.8%	97.8%	97.2%	99.2%	98.5%	98.5%

3.1.2 pH value

The results are in Table (2) and the values are represented in Fig. (3)For samples of meat and slaughterhouse waste water shows that:

The enfluent of raw water pH is ranged from 7.1 to 7.8.

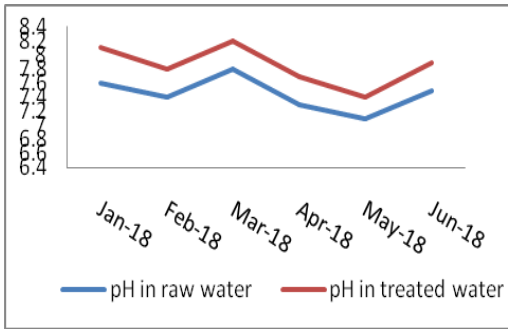

Fig.3. pH analysis of raw and treated samples from meat and slaughterhouse industry in Tanta

And the effluent of treated water pH was ranged from 7.4 to 8.3.

3.1.3 Biochemical oxygen demand (BOD).

Figure (3); the data shows the removal percentages of BOD of Meat and Slaughterhouse industry in Tanta using electro-coagulation techniques, the BOD values were decreasing with increasing both applied electric current and retention time. The study found that, the BOD content of raw domestic wastewater from meat and slaughterhouse ranged between 845 and 1054 mg/L.

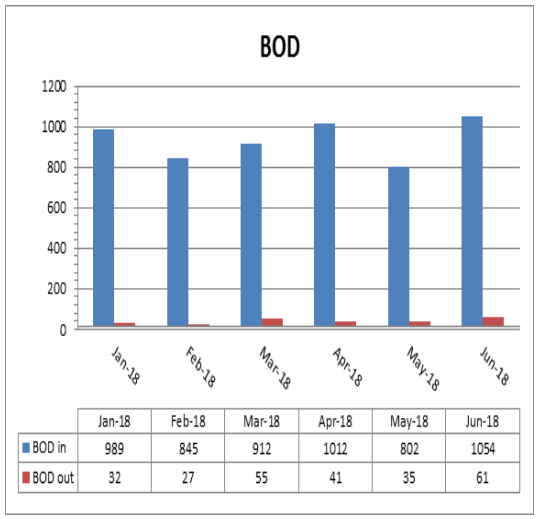

Fig.4. BOD analysis of raw and treated samples from Meat and Slaughterhouse industry in Tanta

In this work, results have represented in Fig. (4) Indicate that the BOD content after treatment which ranged between 27 and 61 mg/L. The same results have been reported. The lowering of final pH may be explained by that aluminum complexes more easily hydroxide than the iron ones. Similar observation were found, the removal percentages of BOD were reached to 96% (8). The data in Fig.5 show that the electrocoagulation removal efficiency of BOD in the treated samples from meat and slaughterhouse industry in Tanta is ranged between 94 % to 96.8 and the average of the removal efficiency of BOD was 95.6 %.

3.1.4 Total suspended solids (TSS).

The values have been graphically represented in Fig. (6) Indicate that the TSS content of raw wastewater ranged between 545 and 868 mg/L. The current density has a greet effect on the removal efficiency of COD.

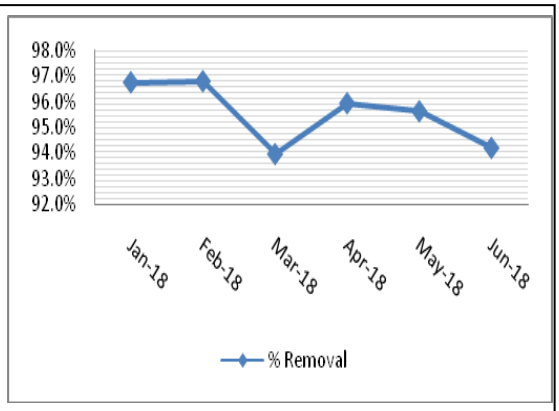

Fig.5. BOD removal efficiency from meat and slaughterhouse industry in Tanta

The values have been graphically represented in Fig. (6) Indicate that the TSS content after treatment ranged between 23 and 50 mg/L.

As the current density increases the efficiency of releasing aluminum ion increasing according to Faraday's low. Also influence on the operational cost of the process [14].

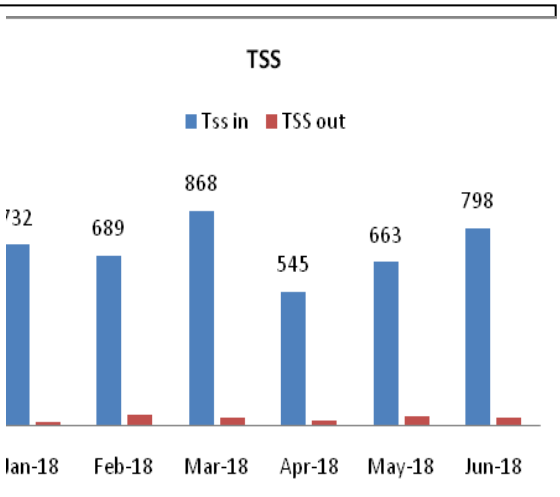

Fig. 6.TSS analysis of raw and treated samples in mg/L from meat and slaughterhouse industry in Tanta

The data in Fig.7 show that the ranges of removal efficiency of TSS are from 92.7 to 96.9 % the average of the removal efficiency of TSS was 94.5 %.

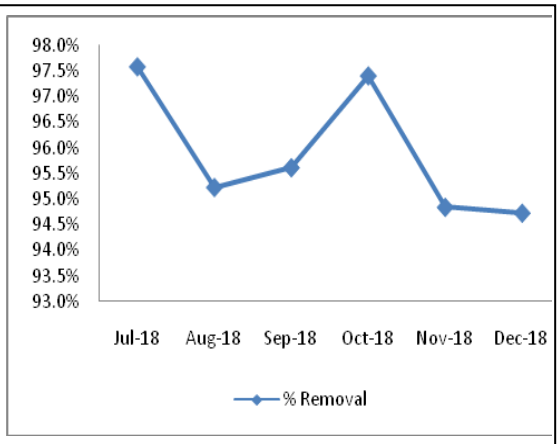

Fig.7. TSS removal efficiency from meat and slaughterhouse industry in Tanta

3.1.5 Chemical Oxygen Demand (COD).

COD is the measurement of amount of oxygen by chemical oxidation of organic matter present in wastewater.

The values have been graphically represented in Fig. (8) indicate that the COD content of raw domestic wastewater from meat and slaughterhouse ranged between 1210 and 1870 mg/L.

Results represented in Fig. (8)Indicate that the COD content after treatment are ranged between 29 and 78 mg/L.

A hybrid electrocoagulation with mixed electrodes of iron and aluminum and sodium sulphate Na_2SO_4 and pH = 7.8 the removal of COD was 94.4 %of its initial conc. 1.200 mg/L.

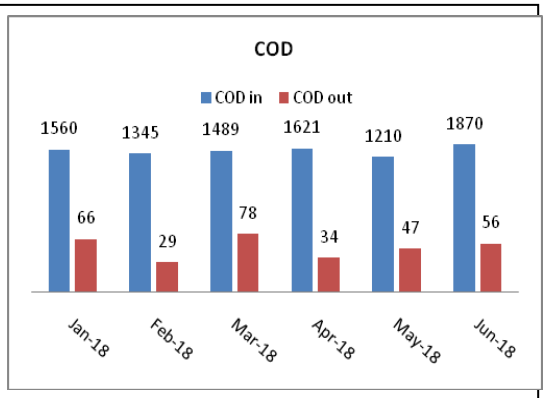

Fig. 8. COD analysis of raw and treated samples in mg/L from meat and slaughterhouse industry in Tanta

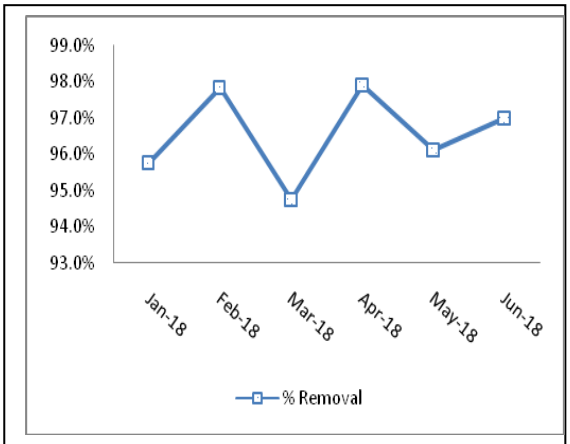

Fig.9. COD removal efficiency from meat and slaughterhouse industry in Tanta

The data in Fig.(9) show that the electrocoagulation removal efficiency of COD in the treated samples of Meat and Slaughterhouse industry in Tanta samples are ranged between 94.8 to 97.9% and the average of the removal efficiency of COD was 96.6 % .

3.1.6 Oil and Grease (O&G).

A lot of studies for the oily indicate that electrocoagulation floatation treatment method destabilizes oil in wastewater emulsion and aluminum electrodes give best removal efficiency [15].

The values have been graphically represented in Fig. (10) Indicate that the oil and grease content of raw domestic wastewater from Meat and Slaughterhouse industry in Tanta ranged between 123 and 251 mg/L.

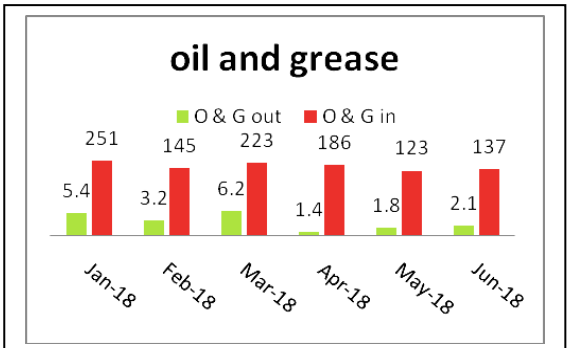

Fig.10. Oil and Grease analysis of raw and treated samples in mg/L from meat and slaughterhouse industry in Tanta

Results represented in Fig. (10) Indicate that the oil and grease content after treatment are ranged between 1.4 and 6.2 mg/L

The data are graphically represented in Fig. (11) Show that the electrocoagulation efficiency of the oil and grease in the treated samples of meat and slaughterhouse samples are ranged between 97.2 to 99.2% and the average of the removal efficiency of the oil and grease was 98.1 %.

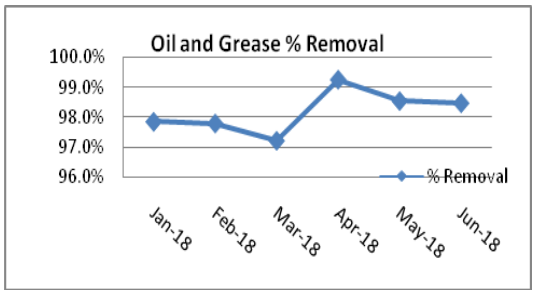

Fig. 11.Oil and Grease removal efficiency from Meat and Slaughterhouse industry in Tanta

4. CONCLUSION

From this study the electrocoagulation method for treating the waste water which including high content of pollutants after coagulation process the removal efficiencies are 96 % for BOD, 96.6 % for COD , 98.1 % for Oil and Grease , and 94.5 % for TSS .Finally, a successful application of electro-coagulation (EC) technique for the removal of suspended solids from wastewater would address the environmental needs of reduction in the operational costs and potential saving in processing unit. Electro coagulation method offers a special attraction due to its ecologically friendly, safety, simplicity and lower operating costs.

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الملخص العربى :

اجريت هذه الدراسة للتحقق من امكانية استخدام طرق جديدة تستخدم لمعالجة المخلفات السائلة بواسطة التخثر الكهربى وميكانيكية المعالجة تشمل علي عمليات الترويب والامتزاز والترسيب والتعويم للمواد العالقة .

وتعتمد هذه الطريقة على امرار تيار كهربي مستمر عبر قطبين احدهما انود ويحدث تفكك لايوناته والاخر كاثود يحدث عنده تكوين غازات الهيدروجين والاكسجين ويتكون ايون الهيروكسيل الذي يتحد مع الايونات المتفككة من الانود والتى تكون عبارة عن ايونات الحديد والالمونيوم مكونة هيدروكسيد الحديديك او الالمونيوم التى تعتبر الندف التى تعمل على تجميع المواد العالقة وترسيبها .

- **تتميز عن الطرق التقليدية مثل التخثر الكيميائي بالمميزات التالية :**

1- تقنية بسيطة وتحتاج الي تكاليف تشغيل وصيانة منخفضة.
2- تقلل من الاملاح الكلية الذائبة فى المياه المعالجة .
3- التيار الكهربي يساعد علي ترسيب المواد الغروية صغيرة الحجم .
4- فقاعات الغاز المتكونة عند الكاثود تعمل علي تعويم الملوثات الاقل فى الكثافة على السطح .
5- كمية الحمأة الناتجة من هذه التقنية تكون قليلة بالمقارنة مع الطرق التقليدية الاخرى .
6- القدرة على معالجة العديد من الملوثات .
7- التكلفة الاستثمارية لها منخفضة بالمقارنة بالطرق الاخرى للمعالجة .

وتم عمل التجارب والقياسات على مياه الصرف الصناعى فى المجزر العمومى بطنطا

وكانت النتائج قبل المعالجة وبعدها وايضا كفاءة ازالة الملوثات كالتالى :-

- **المواد الكلية العالقة** وكانت النتائج التى اجريت قبل المعالجة تتراوح من 545 مجم/ل الى 868 ملجم/ل بينما بعد المعالجة كانت تتراوح من 23 ملجم/ل الى 50 ملجم /ل وكانت كفاءة ازالة المواد العالقة 94.5 % .
- **الاكسجين الكيميائى المستهلك** وكانت النتائج التى اجريت قبل المعالجة تتراوح من 1210 مجم/ل الى 1870 ملجم/ل بينما بعد المعالجة كانت تتراوح من 29 ملجم/ل الى 78 ملجم /ل وكانت كفاءة ازالة الاكسجين الكيميائى المستهلك 96.6 % .
- **الاكسجين الحيوى الممتص** وكانت النتائج التى اجريت قبل المعالجة تتراوح من 845 مجم/ل الى 1054 ملجم/ل بينما بعد المعالجة كانت تتراوح من 27 ملجم/ل الى 61 ملجم /ل وكانت كفاءة ازالة الاكسجين الكيميائى الممتص 95.6 % .
- **الزيوت والشحوم** وكانت النتائج التى اجريت قبل المعالجة تتراوح من 123 مجم/ل الى 251 ملجم/ل بينما بعد المعالجة كانت تتراوح من 1.4 ملجم/ل الى 6.2 ملجم /ل وكانت كفاءة ازالة الزيوت والشحوم 98.1 % .

ومن خلال الدراسة البيئية نجد ان جميع نتائج تحاليل العينات لمياه الصرف الصحى المعالج جميعها مطابق للكود المصرى للصرف على المجارى المائية وتتميز تقنية المعالجة باستخدام التخثر الكهربى بان كمية الحمأة الناتجة من المعالجة منخفضة جدا بالمقارنة بالطرق التقليدية الاخرى .