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TREATMENT OF PALM OIL MILL EFFLUENT USING EVAPORATION AND ADSORPTION TECHNIQUES

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ABSTRACT

The bench scale experiment was carried out with an aim to treat the palm oil mill effluent by utilising it's physical and chemical characteristics. The raw effluent has a temperature of 80 - 85°C, thus by introducing a vacuum of 350 mm Hg, the effluent will evaporate without any addition of heat. The vapour produced was then passed through a bed of adsorbent. Four different types of adsorbents were studied in this part namely activated carbon, natural zeolite and synthetic zeolite of the X and A type. The vapour, (before adsorption) when analysed showed a 99% removal of most polluting parameters monitored except for pH, COD and BOD. The effluent was able to be concentrated to as high as 25% solid content from the initial content of 3 - 5% solids. This will result in a recovery of 80% of the water content and also the POME volume will reduce by the same percentage. The concentrated effluent analysis showed a high content of nitrogen, phosphorus and potassium which can be used as feed material for the making of fertiliser. Next, the adsorption process results indicated that the synthetic zeolite gave a batter treatment then that of the natural adsorbents.

Key words: Palm Oil Mill Effluent, Vacuum Evaporation, Adsorption

INTRODUCTION

Malaysia is well known for it's edible oil products and palm oil tops this list in terms of production and also monetary returns. The extraction of palm oil from the palm fruit is a very well established process and it is widely applied in Malaysia. But this extraction process creates a brown effluent which can devastate any aquatic life if dumped directly into our rivers. It is estimated that for every tonne of palm oil produced, 2.5 tonnes of wastewater is generated. Thus, with Malaysia's production of palm oil standing close to 8 million tonnes per annum, the amount of palm oil mill effluent (POME) generated would be equivalent to that of sewage discharged by a population of 22 million people. [1 - 8]

Palm oil mill effluents are high volume liquid wastes which are non toxic but have an unpleasant odour. They are predominantly organic in nature and are highly polluting. The Biological and Chemical Oxygen Demand (BOD & COD) of this effluent is very high and so goes for the Total Nitrogen, Ammonical Nitrogen and Oil & Grease. The effluent is also acidic. Other than this the raw effluent is made up of a few anions and cations. As for the physical nature of the raw effluent, it is hot, has a bad aroma and is brown in colour. Thus, if such an effluent with it's quality and quantity were to be discharged into our rivers, all aquatic life will perish. [9 - 11]

At present there are many method of treating this raw effluent. The most common method of treatment being employed is the biological treatment. Basically this method of treatment is by using a combine effect of the aerobic, anaerobic and facultative treatment pond, where at the end of the treatment the effluent is dumped into a nearby stream or river. Alternatives treatment methods have propped up in the recent past. These methods of treatment are new and under study. For example, there is a proposal to use this effluent direct on the farm land by overhead spraying or to allow it to dry up in open lagoons. There is also research being done to treat the effluent using filtration, centrifugation, heat assisted evaporation and also reverse osmosis. [12 & 13]

This study will concentrate on utilising the physical and chemical characteristics of the POME to treat it. The raw effluent that is produced in the mill is of 80 - 85°C, thus by evaporating the effluent by just adding a vacuum to reduce the boiling point all the water could evaporate. This will give a concentrated sludge and the collected distillate. The next step is to treat the vapour produced. It is proposed to pass the vapour through a bed of adsorbent. *Figure 1* shows the schematic diagram of the proposed treatment plant if it were to be implemented into the present palm oil mill.

MATERIALS AND METHODS

The raw effluent was obtained from Ladang Pengelli, which is a Felda Plantation in Bandar Tenggara, Johor. This effluent was collected in air tight cans and then stored in a refrigerator between 3 - 5°C. This was done to prevent any distortion to the effluent before the experiment could be carried out. Next the bench scale apparatus were set up as shown in *Figure 2*. The evaporation process was carried out in a three neck flask which was placed on a heating mental which has a thermocouple and also a sensor to monitor and control the heat of the fluid in the flask. The sensor was inserted into the flask using the left neck together with a pressure gauge to monitor the vacuum pressure in the flask. The right neck was fitted with a thermometer. Lastly the centre neck was fitted with a adsorption column 1 ft. in length and with a inner diameter of 5 cm. This will ensure that all the vapour produced will pass through the adsorption column. The heating mental is used to maintain the POME in the flask at 80 - 85°C, which is the temperature of the raw effluent in an actual palm oil mill. Once the vapour produced has passed the adsorption column, is will be cooled using a condenser and the distillate

collected. A vacuum pump is introduced at the end of the system to keep the system under a vacuum pressure of 350 mm Hg.

The experiments were divided into a few parts for various study to be carried out. In the first part, only evaporation was carried out without any adsorbent to study the effect of temperature and pressure. Next the adsorption process was done to find the weight and time needed to treat the distillate. Four different types of adsorbent will be studied, namely activated carbon, natural zeolite and synthetic zeolite of the A and X types..

RESULTS AND DISCUSSIONS

Evaporation

The distillate, raw POME and also the concentrated sludge after the evaporation process was analysed and the results are shown in *Table I*. The duration of the process was for 90 min and the adsorption column was filled with inert material only. The initial volume of POME used was 800 ml and 550 ml of distillate was collected. This will give a 70 % recovery of water from the effluent and the volume of the effluent too reduced by the same percentage. As for the polluting parameters monitored, except for pH, COD and BOD, all other parameters showed a 99% removal. This shows that the evaporation process is successful in treating and also recovering water from wastewater. The quality of the distillate is good except that it is acidic and the dissolved oxygen in it is low. Another point, is the fact that most of the polluting parameters checked in the distillate also shows that they are below the environmental standards.

Evaporation is a process where, when a certain liquid reaches its boiling point it will boil and evaporate, leaving behind all other material or substances it was in combination with in its liquid phase. Therefore, when the POME boils, only water is evaporating where else all other material in the POME will remain in the liquid phase because they only boil at temperatures higher than the operating temperature. This will account for the quality of the vapour. An analysis of the distillate using ion chromatography, showed that the vapour produced contained a substantial amount of florin ions. These ions could be the cause of the distillate being acidic. As for the oxygen demand the reason that this parameter still gives a high value is because the system is under vacuum and there is no oxygen added into the system and also the demand is due to the acidic nature of the distillate.

Checks were carried out on the raw POME obtained from the factory and the analysis showed that the pollutant level of the wastewater is in the same range as other factories in Malaysia as sited in available literature. Lastly the concentrated sludge analysis showed that the solid content has rose from 4.1% to 15.1%. The analysis also showed that the sludge contained a high value of Nitrogen, Phosphorus and Calcium which is good to be used as feed material to the fertiliser industry or dumped directly into the palm oil estate.

Pressure Influence Towards The Evaporation Process

The next step was to determine the effect of pressure and it's corresponding temperature on the evaporation process. All runs were for 30 min and a steady vapour production was achieved. The results of the distillate analysis are in *Table II.* From the results obtained, it can be said that pressure and temperature does not effect the quality of the distillate. This is because the constituents of the POME are basically made up of organic matter which have a boiling point of above 100°C, thus by reducing the boiling point of the wastewater will not effect the distillate that is produced. The results show that all parameters monitored have a certain range. From this results a conclusion was made that all further experiments will be carried out at the temperature of the raw effluent which is at 80 - 85°C and a vacuum of 350 mm Hg.

Adsorption Process

The adsorption process results were put into graphs and are shown in figures 3 to 14. Generally the synthetic adsorbents have performed batter than the natural adsorbents. Each parameter studied and its results are discussed in the following paragraphs.

Effect of Adsorbents on pH

The effects of the various adsorbents on the pH of the distillate are shown in *Figures 3, 4, 5, and 6.* The aim of this part is to see the effectiveness of the adsorbents used in removing the florin ions present in the distillate without adding any other contaminants. From the analysis of the four figures, it is quite clear that the "X" and "A" type zeolite is efficient in neutralising the acidic distillate. The synthetic zeolite are designed to treat wastewater and to remove impurities, thus giving such good effects. As for the natural adsorbents, they may contain other constituents which could dissolve or react with the vapour upon contact. This will hinder the treatment process, consequently reducing the effectiveness of the adsorbent. From the figures, it also shows that about 10 g of the "A" type zeolite is enough to treat the vapour produced. The graphs likewise show that the pH of the vapour is reducing with time. This could be that the adsorbent is being saturated and as time goes on , the pH of the distillate returns to the pH of the untreated distillate. This could also be taken as the break through time of each adsorbent towards this parameter..

Effect of Adsorbents on COD and BOD

The effect of various adsorbents on the COD of the distillate are shown in *Figures 7, 8, 9, and 10.* The trend of the graphs that show the relationship between COD and time is the same as the relationship shown between BOD and time. This can be concluded by studying the next four graphs in *Figure 11, 12, 13, and 14.* From the figures, again the "X" and "A" type zeolite has given the best results. The percentage of reduction is about 40 to 60% for these two adsorbents. Again, the synthetic zeolite has removed the florin ions thic reducing the chemical content in the effluent. When the chemical content is

reduced, so will the oxygen demand in the distillate be reduced. The COD is related to the BOD and the value of BOD will follow suit if the COD value goes down and wise a versa. As for the Natural Zeolite and Activated Carbon the percentage of reduction is much lower.

CONCLUSION AND RECOMMENDATIONS

From the experiments carried out, it shows that the evaporation process combined with the adsorption process is a good solution to the problem posed by POME. All results showed good removal of pollutants and it also complied with environmental standards. Thus, full use can be made of the energy in the effluent to solve the wastewater problem. Using this method too there will be no effluent to be dumped because the distillate can be either recycled in the plant for process water and the concentrated sludge can be sold to the fertiliser company for a source of income. Thus, the effluent which was a problem in the past is now a income generating product of the palm oil mill.

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TABLE I : EVAPORATION ANALYSIS DATA

Parameter Monitored	Distillate	Raw POME	Concentrated Sludge	Malaysian Environmental Standards
pH	3.94	4.89	4.65	5.0 - 9.0
COD	1,250	61,000	180,500	100
BOD_5	815	35,150	98,500	50
Total Solids	110	41,200	151,000	NA
Suspended Solids	1.5	20,650	54,200	100
Volatile Suspended Solids	1	16,000	45,500	NA
Ammonical Nitrogen	0.8	47	151	NA
Oil & Grease	8.5	10,500	38,800	10
Mg	0.2	442	1,020	1
Ca	0.1	71	199	NA
K	0.8	3,365	7,445	NA
F	32	591	4,750	NA
Cl	0.2	1,742	11,449	NA
NO_3	0.06	92	791	NA
SO_4	0.35	322	3,224	NA

* All units are in (mg/L) except for pH

TABLE II : PRESSURE AND TEMPERATURE EFFECT ON POLLUTING PARAMETERS

Vacuum Pressure (mm Hg)	Corresponding Temperature (°C)	pH	COD (mg/L)	BOD (mg/L)	T. Solid (mg/L)	F (mg/L)	Cl (mg/L)	K (mg/L)
550	65	3.34	1420	1025	112	29	0.00	0.65
525	71	3.31	1340	920	101	26	0.09	0.71
490	75	3.32	1290	870	95	26	0.00	0.69
380	83	3.28	1380	960	107	27	0.10	0.80
330	85	3.24	1200	820	95	32	0.07	0.69
250	90	3.27	1160	810	102	31	0.03	0.76
130	95	3.29	1310	950	111	32	0.06	0.74
0	100	3.30	1330	980	94	34	0.07	0.69

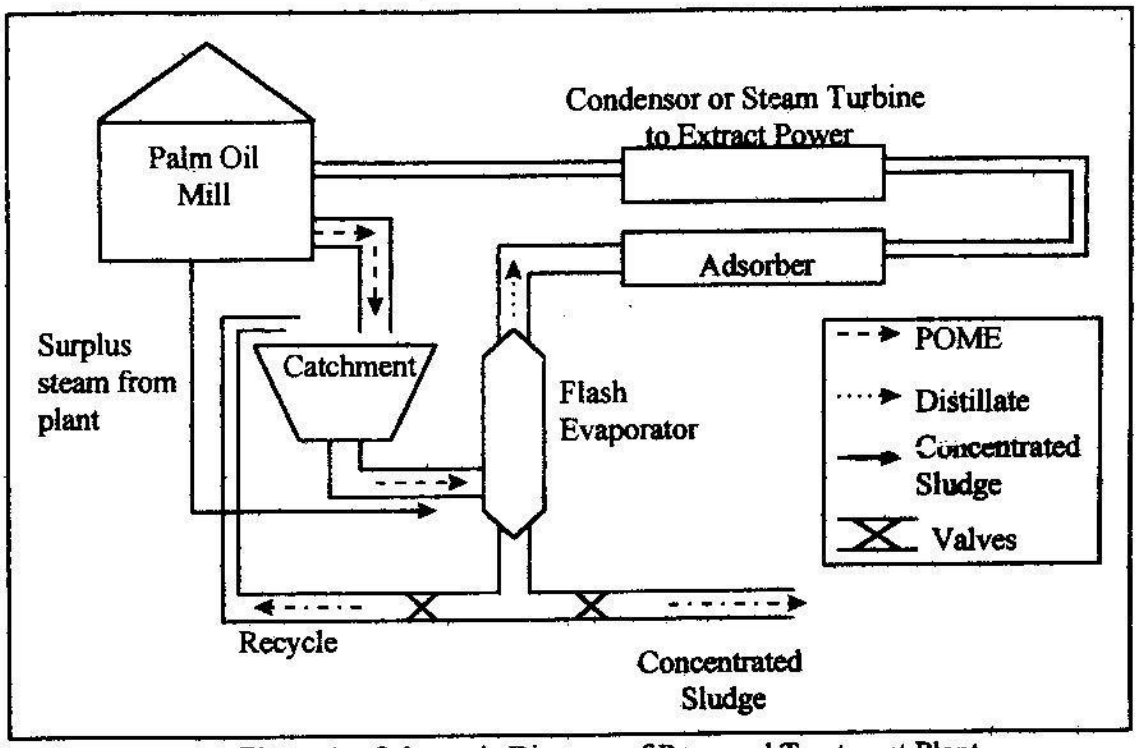

Figure 1 : Schematic Diagram of Proposed Treatment Plant

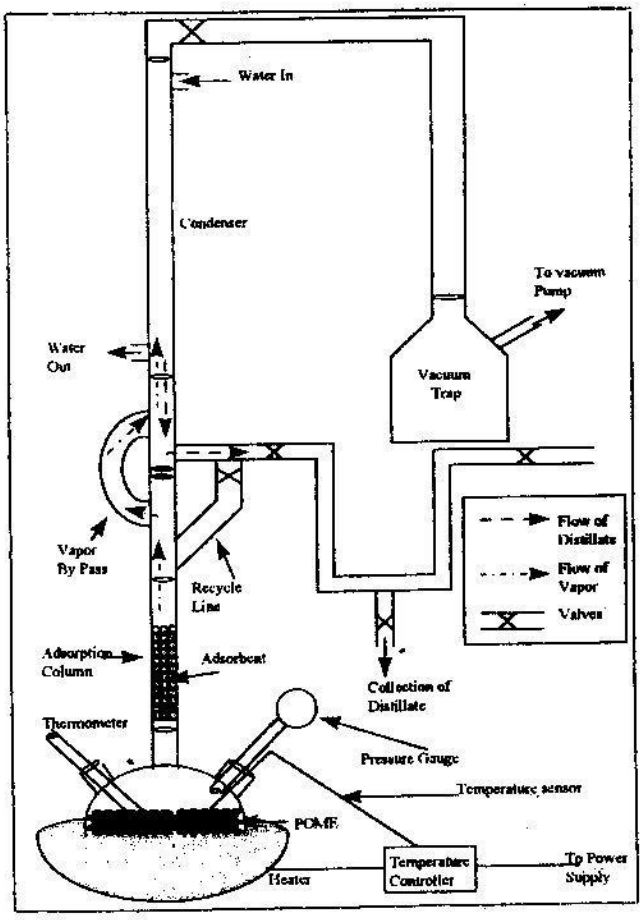

Figure 2: Schematic diagram of experimental rig.

Figure 3: Time of Adsorption Vs pH for different weights of Activated Carbon

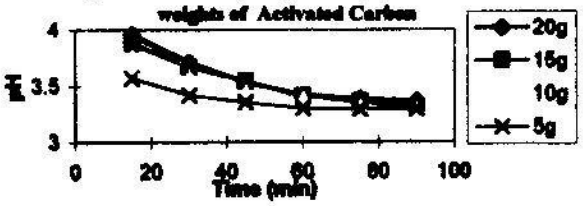

Figure 4: Time of Adsorption Vs pH for different weights of Natural Zeolite

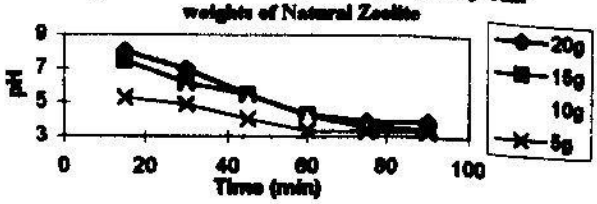

Figure 5: Time of Adsorption Vs pH for different weights of "A" Type Zeolite

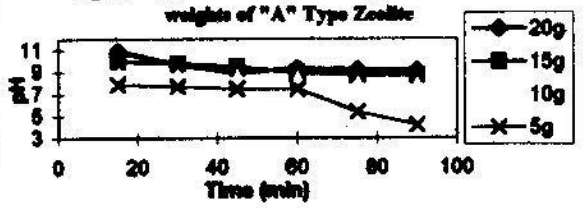

Figure 6 : Time of Adsorption Vs pH for different weights of "X" Type Zeolite

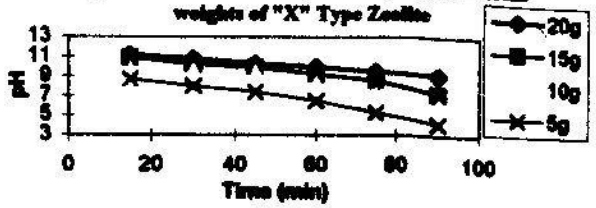

Figure 7: Time of Adsorption Vs COD for different weights of Activated Carbon

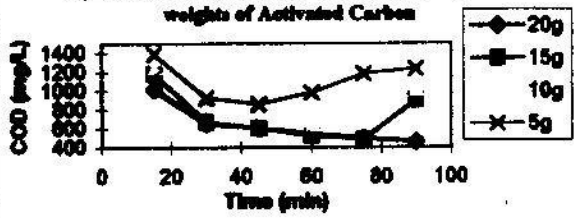

Figure 8: Time of Adsorption Vs COD for different weights of Natural Zeolite

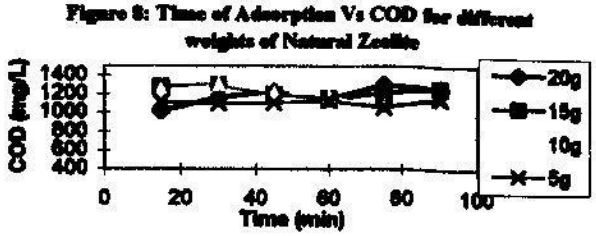

Figure 9: Time of Adsorption Vs COD for different weights of "A" Type Zeolite

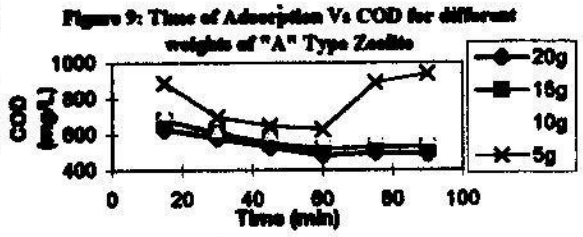

Figure 10 Time of Adsorption Vs COD for different weights of "X" Type Zeolite

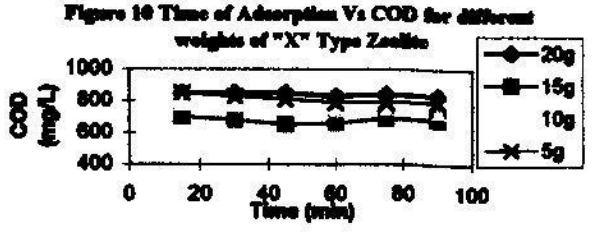

Figure 11: Time of Adsorption Vs BOD for different weights of Activated Carbon

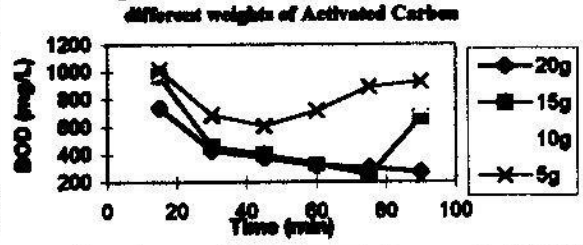

Figure 12: Time of Adsorption Vs BOD for different weights of Natural Zeolite

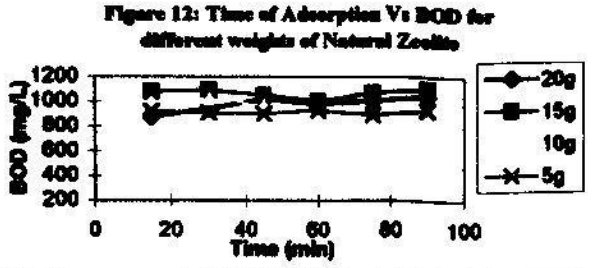

Figure 13: Time of Adsorption Vs BOD for different weights of "A" Type Zeolite

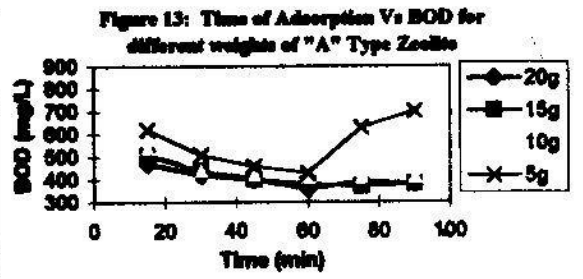

Figure 14: Time of Adsorption Vs BOD for different weights of "X" Type Zeolite