POLLUTION CONTROL A CATALYST FOR MORE EFFICIENT PROCESS: THE PALM OIL INDUSTRY AS AN EXAMPLE

By E.A.R. Ouano, Ph. D.

Abstract

The pollutant generated from an industry is part of the raw materials purchased by the industry. The higher the pollution generated from an industry the higher is the raw material wastage and pollution control cost. The cost of pollution control could be reduced by improving the process efficiency of the conversion of raw materials to useful products or by-products.

Industrial processes are often developed by mere mechanization of primitive practices. A typical example of which is the palm oil industry. For every ton of fresh fruit, 0.7 to 1.0 ton of waste materials are discarded to rivers and streams in terms of Biochemical Oxygen Demand (BOD). The wastewater are very strong with BOD concentrations of 20,000 to 30,000 mg/l which is 100 to 150 times stronger than ordinary sewage. An average palm oil processing mill with a capacity of 1000 tons/day dumps to the river, a pollutant load equivalent to a city with a population of 2,500,000 persons. The oil palm industry is a major pollution source in Malaysia exceeding the total organic wastes generated from other sources. The Philippine oil palm industry is still in its infancy but next two or three years it will be a major source of water pollution which will surpass current pollution sources.

A critical review of the existing palm oil extraction process is made with regards to sources of pollution or materials wastage. Current attitude has been to treat the wastewater or recover the by-products from the wastewater which could be inefficient due to the dilution and presence of a wide range of impurities. A new method of sterilizing the fresh fruit bunch, and oil is presented. Instead of generating wastewater, a 0.2 to 0.3 ton of animal feed with composition similar to copra meal cake could be recovered. The oil recovery is increased by 10-15% since hydrolysis is minimized. The test has been carried out in the laboratory and Pilot plant testing maybe required before further commercial application is possible.

With the pollution requirements on the industrial discharge, the need to reinvestigate the rationale of the different industrial processes has to be carried out.

Introduction

For every ton of fresh fruit bunch (ffb) of palm oil processed 0.700 to 1.0 ton of wastewater is generated from sterilizer condensate and sludge separation. The wastewater organic content is 100 times stronger than sewage in terms of BOD or Biochemical Oxygen Demand. Hence, a typical 50 t/hr palm oil processing mill will generate 200 tons of wastewater per day with a total BOD load of 24,000 kg/day. The pollutant load from this factory is equivalent to the total untreated sewage from a city with a population of 2,500,000 people discharged at one particular point in a river.

The environmental degradation caused by palm oil is one of the major constraints the Malaysian government had considered in the development of new plantation in Pahang State in 1975. The environmental controls for new plantation were enforced stringently such that some foreign companies' plans for expansion were transferred to other countries where palm oil pollution is unheard of like the Philippines and Papua New Guinea.

EXISTING OIL PALM EXTRACTION PROCESS

In order to appreciate the wastewater pollution problem of an oil palm processing mill it is worthwhile to review the evolution of the current process used in Malaysia, Indonesia and African Guinea. The process is most likely the same process that will be used in the Philippines in the near future when the existing plantation reaches productivity.

Palm oil is extracted from the pulpy portion (mesocarp) of the fruit *Elaesis guieansis*, which is a native of the West African Guinea Coast. The tree was introduced by the British and Dutch into Southeast Asia in the 19th century. Today most of the world's palm oil are produced in Malaysia, Indonesia, Thailand and African Guinea. The plant has been used for oil and food by African natives of Guinea long before the colonization of the West African coast in the 16th century. The extraction process was developed through experience and intuition with the skills passed on from one generation to another.

The African natives cook the fresh fruit bunch in boiling water for two to three hours right after harvesting the fruit. If the fruit is not cooked right after harvesting, the oil content declines and the oil extracted contains more fatty acids. In fact 48 hours after harvesting almost all the oil in the mesocarp are hydrolyzed to glycerol and fatty acid due to the presence of hydrolyzing enzymes in the mesocarp. Bruises in the fruit accelerates the release of the hydrolyzing enzymes to the oil globules.

After the cooking operation, the mesocarp is separated from the kernel. The floppy mesocarp is mascerated and pulped to a slurry consistency. The slurry is allowed to stand for an hour or two so that the oil will float and separate from the denser sludge. After separating the oil, the sludge is discharged.

The boiled water used for cooking the fruit and the discarded sludge are major sources of wastewater. However, on a family scale processing of palm oil the wastewater volume is very low that it could be discarded without any problem.

The process commonly used today is a simple mechanization of the same process used by the African natives. Initially, the fresh bunch is subjected to steam under a pressure of 2.5 to 3.2 kg/cm^2

for 50-70 minutes to loosen the fruit from the bunch and deactivate the enzymes. After the cooking operation the bunch and the cooked fruit are separated in a rotary drum. The bunches are used for fuel in the boilers and furnaces, which is often more than sufficient to meet the energy needs of the plant.

The cooked or sterilized fruit is converted to an oily mash by a series of rotating screws. The mash is then passed through a centrifuge to separate the oil from the mash. The mash is discharged as wastewater together with the sterilizer condensate. The processing operation is shown in Fig. 1. For each ton of fresh fruit bunch 230-250 kg. of oil is recovered.

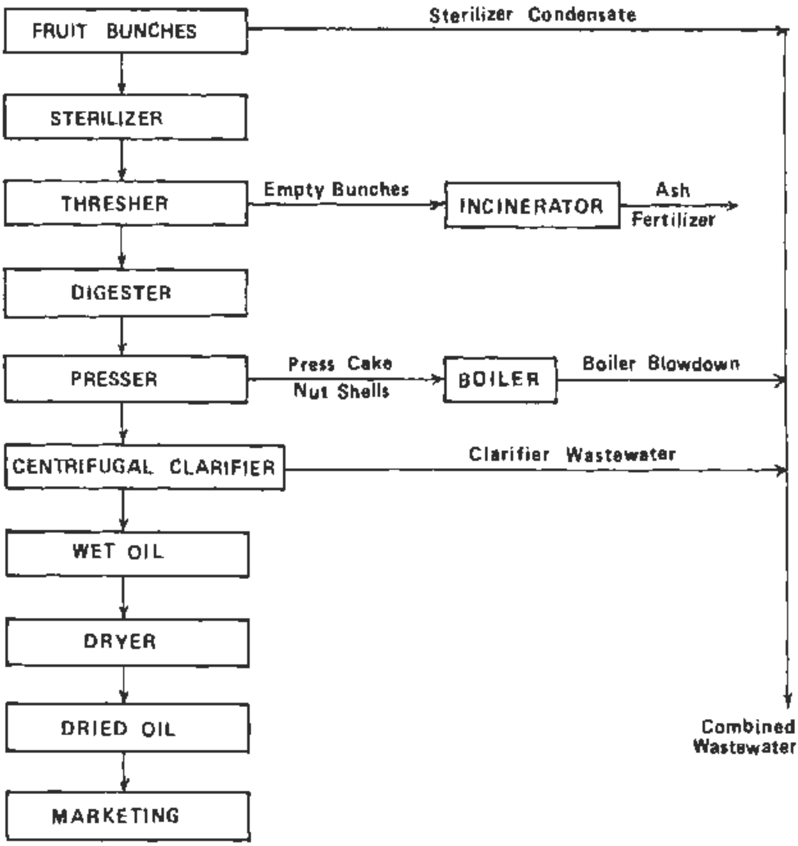

Figure 1. Palm Oil Extraction Processing in Malaysia.

WASTEWATER CHARACTERISTICS

The palm oil wastewater is difficult to treat using conventional biological wastewater treatment process for the following reasons:

a) The waste is highly deficient in nitrogen in comparison to the organic impurities expressed in terms of BOD. The ideal N to BOD ratio for aerobic biological treatment should be 5:100 whereas on the palm oil mill wastewater the maximum nitrogen to BOD ratio is only 1.6 to 100.

   Although the nitrogen deficiency could be alleviated by adding urea or other nitrogen fertilizer, 1 kg of urea will be required for every ton of wastewater or approximately 4 kg of urea will be required to treat the wastewater generated in producing one ton of palm oil. Considering the existing cost of ₱3.00/kg of urea, it would cost ₱12.00 of urea/ton of oil produced.

b) Very High BOD — The organic concentration is very high that to use anaerobic/facultative lagoon system, 0.20 ha of land would be required for the wastewater treatment process for every hectare of land cultivated for oil palm. If a surface aerator is used 40 kg of oxygen is required for every ton of wastewater produced or 160 tons of oxygen for every ton of palm oil produced. With the present aerator oxygenation capacity of 1 kg of O_2 per kw—hr, 160 kw-hr will be required for every ton of oil produced or approximately ₱80/ton of palm oil.

c) The wastewater contains a high concentration of volatile fatty acid and has a very low alkalinity for buffering. The pH of the wastewater varies from 3.7 to 4.8 when the required pH for biological degradation is from 6.5 to 8.0. Even when lime is added for pH adjustment for anaerobic degradation, the pH will return to acidic conditions due to poor buffering capacity. The wasterwater treatment process is very unstable due to high BOD and low buffering capacity.

d) The excess nitrogen and phosphorus will have to be removed otherwise the effluent could cause euthropication problem specially in lakes and closed bodies of water.

Typical wastewater characteristics of the palm oil mill is shown in Table 1.

Table 1. Characteristics of Palm Oil Wastewaters

Characteristics, mg/l (except as indicated)	*Sterilizer Condensate*		*Clarification Sludge*		*Combined Wastewater*		
	1/	*Present Study*	1/	*Present Study*	1/	2/	3/
BOD	18,000		20,000		18,000-20,000	19,8000	14,000-16,000
COD	55,000	59,700	60,000	87,760	40,000-58,000		29,000-40,000
Suspended Solids	15,000	10,600	35,000	11,000	30,000	15,420	4,800-5,400
Dissolved Solids	25,000		25,000		35,000	23,500	16,000-27,000
Oil(%)	0.7		0.7		0.7	.57	
pH	4.5	4.75	4.5	3.7	4.5	4.8	4.4-4.5
NH_3-N	—		—		30	25	39
NO_3-N	—		—		9.3	41	9.3-10.4
Org-N	—		—		576	522	
Total-N		700		756			
Phosphorus		150		150	200		
Temperature, °C					80-90		
Volatile Acids		2820		3990			
Alkalinity		1400		nil			

1/ MA, A.N. (1975), Agro-Industrial Waste Problems in Malaysia, Proceedings of the Agro-Industrial Waste Symposium, Kuala Lumpur. MUTHURAJAH, K.N. (1975), Some Aspects of Palm Oil Mill Effluents and Possible Methods of Treatment, Proceedings of the Agro-Industrial Symposium, Kuala Lumpur.

2/ SINGH, K. and NG, S.H. (1968), The Malaysian Agricultural Journal, v. 46, no. 3, Jan., pp. 316-323.

3/ AZIZ, A.B. (1974), Palm Oil Processing Effluent Treatment, v. 1, Factories and Machinery Department, Kuala Lumpur.

CURRENT WASTE TREATMENT PROCESS

From Table 1, the wastewater has a high concentration of suspended solids which varies from 15,000 to 33,000 mg/l depending on the in plant water consumption and availability. Most of the organic pollutants are in the form of suspended solids rather than in colloidal or dissolved form. Air flotation have been utilized to remove the solids. From 60-40% of the organic pollutant is removed with the suspended solids but from 40-50% of the pollutant remains in solution or colloidal dispersion. The process is useful in pretreatment and reduction of the organic pollutant but the equipment is quite expensive and difficult to operate. In addition coagulant aid and coagulating agents are required in substantial concentration for the process to function satisfactorily. For this reason the process have not been utilized extensively except in pilot plant scale.

Irrigation or land disposal of the wastewater have been tried in Malaysia. The wastewater could be dosed on land up to 4 cm deep once every four months without any noticeable effect on the soil quality even after 2 years of operation. However, plantations are often located in rolling hills and hilly terrain that extensive piping and pumping is required.

A complex integrated process known as CENSOR (Centrifugal Solid Recovery) has been proposed by researchers at the University of Malaya. The process involves the reduction of the wastewater moisture content from 95-90% using conventional plate centrifuge "Westphalia" or a three stage decanter centrifuge "Sharpless". The moisture in concentrated sludge is reduced by adding cassava meal and palm oil kernel meal as an absorbent, carbohydrate and protein base. The mixture is dried at high temperature using a high air speed injection type rotary drum drier. The final product is pelletized and marketed as animal feed.

In 1975 it has been estimated that the investment from such process could be recovered in 2 years for a factory processing 20 tons of ffb/day. To meet the cassava requirement of the process approximately 0.1 hectare of land will be cultivated per hectare of palm oil cultivated. The processing and production of cassava starch is not pollution free. The upper Gulf of Thailand is polluted mainly from cassava processing waste which is as difficult to treat as the palm oil wastewater. Hence, the process does not solve the problem but merely shift the palm oil pollution to cassava pollution.

DEVELOPMENT OF A NEW PROCESS

The major shortcomings of the present approaches for pollution control of the palm oil mill wastewater has been to consider the wastewater as an essential component of the palm oil processing operation. As described before, the present palm oil extraction process is nothing more than a mechanization of the traditional process evolved by the natives of African Guinea. Due to the low production cost, the incentive to improve the oil recovery process is minimal. The external cost due to environmental damage brought by the uncontrolled discharge of the palm oil wastewater, could exceed the existing production cost and has become the constraint on future expansion as have taken place in Malaysia today.

Boiling water and steam is only one method for deactivation of the enzymes which hydrolyzes the oil to fatty acid and glycerols. Other methods of enzyme deactivation are available notably heated air which could be used on the existing sterilizer equipment using steam. The oil palm fresh fruit bunch could be dried within two hours using air heated to $140 - 160°C$ and operating at a pressure of 28 psig. The process could be carried out at atmospheric condition but it is preferable to carry out the sterilization at higher pressure to minimize burning the skin of the fruit before the inner portion of the mesocarp have been sterilized. The higher pressure suppressed the boiling point of the fruit moisture content, resulting to more uniform sterilization or enzyme deactivation. The term sterilizer or sterilization is retained although this is a misnomer. Early workers in oil palm processing attributes oil hydrolysis in the palm oil mesocarp to bacteria and microorganism, hence, the cooking process was called sterilization rather than enzyme deactivation.

The fruit will shrink in size by 15% due to dehydration during the sterilization process. The skin and mesocarp becomes brittle and when pressed it dissociates into oily pieces 1-1.5 cm in diameter. The sterilized fruit dissociates easily from the bunch upon shaking.

After sterilization the dried fruit could be segregated from the bunches using the thresher used in existing plants. Unlike the steam sterilized fruits, the dried fruits could be stored up to one week without any deterioration in the oil quality. In the early stages of this study, the fruits were sterilized in Kuala Lumpur and processed in Bangkok.

This would allow better flexibility in mill operation than currently possible. The steam sterilized fruit has to be processed within 24 hours otherwise, microorganism will start growing on the cooked and moist mesocarp to destroy the oil. With heated air sterilized fruit, the equipment could be sized at capacity slightly bigger than the average production capacity, hereby reducing the initial capital cost.

The dried mesocarp after being separated from the kernel by the rotary screw is passed on to a high pressure pressing machine commonly used for coconut oil extraction from copra. Using a laboratory pressing equipment with 30 psig pressure, 50% of the oil in the dried mesocarp could be extracted. For full scale operation higher oil yield could be obtained with higher operating pressure than those possible using the laboratory scale pressing unit.

The remaining 50% of the oil could be extracted by solvent such as hexane. Approximately, 300 kg of palm oil could be extracted per ton of fresh fruit bunch using the process described compared to 250 kg oil per ton of ffb using the existing processes. The higher oil recovery of the process is due to the following reasons: a) in the conventional process, during the cooking operation a large amount of oil forms colloidal emulsion with the condensed water which ultimately ends up in the wastewater. Up to 20 kg of the palm oil/ton of ffb are lost in wastewater. b) the sterilization process with steam, the heat hydrolyzes portion of the oil. From 30-40 kg oil/ton of ffb are lost through the sequence.

The spent cake after hexane extraction could be used as an animal feed supplement; the composition of the cake after hexane extraction are as follows:

Oil	—	2- 5%
Protein	—	12-18%
Ash	—	2- 4%
Carbohydrate	—	30-40%

The above analysis is very similar to copra meal cake which is used extensively for animal feed.

The process diagram is shown in Fig 2. The process does not generate any wastewater and the recovery of the organic constituents of the mesocarp for animal feed is facilitated since the solids does not have to be separated from water and dried. In addition, up to 20% more oil could be recovered, with a process that does away with a serious pollution control problem.

Conclusion

A number of industrial processes were developed when concern for the environment, raw materials, power and by-product utilization was minimal. The waste material or pollutant discharge was once part of the raw materials purchased by the industry. Treatment of the polluting effluent from an industry should be considered a priority for an existing plant. The development of more efficient processes could be stimulated by a properly motivated environmental program.

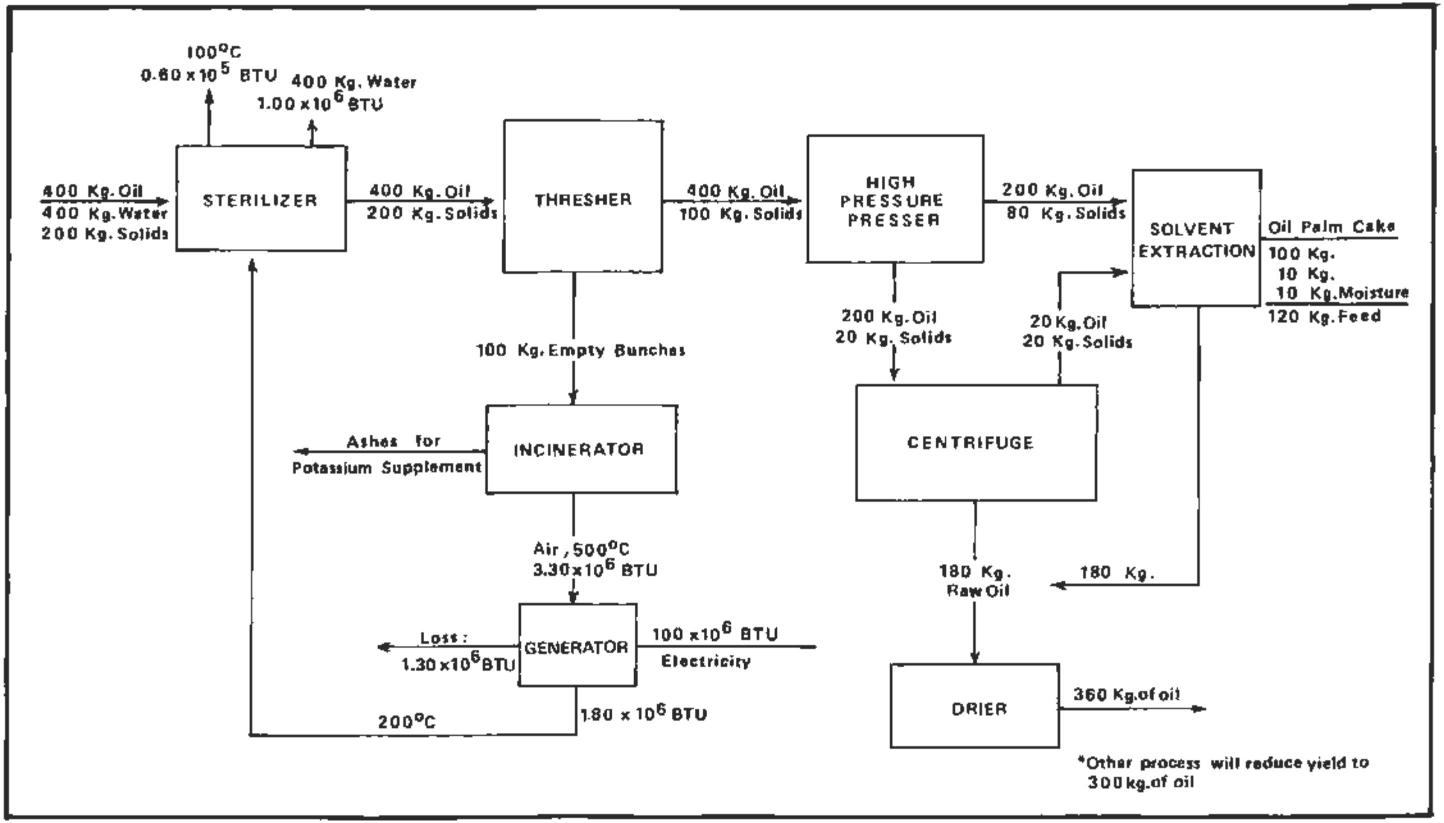

Figure 2. Process Flow Diagram.

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DISCUSSION ON POLLUTION CONTROL A CATALYST FOR MORE EFFICIENT PROCESS: THE PALM OIL INDUSTRY AS AN EXAMPLE

Veronica Villavicencio, Ph.D., Discussant

It certainly augurs well for the cause of environmental protection that a prestigious group such as the National Academy of Science and Technology has devoted one session of its annual scientific meeting to Pollution Control. And I feel that it is also in the right direction, when the topic attempts to view pollution control not as an added cost or a problem area, but as an incentive and a challenge as stated in the title of Dr. Ouano's paper. Too long have we held the view that pollution control measures are purely money down the drain. That they are too expensive and non-economical. For many developing countries that are pursuing the path of industrialization, government planners more often than not have held the view that environmental quality, clean air and water is a luxury which a hungry man or a poor man cannot afford. We certainly sympathize with this view for who can argue that alleviation of poverty must be a priority of the first magnitude. But what is sad is that even as the problem of poverty is alleviated and attitude of resignation and acceptance that pollution is a price that one must pay for industrialization, still continues to prevail. Seldom are the economic gains derived from industrialization funneled back to enhance environmental quality. This has been the trend. So this trend continues until there is public outcry or when really the water is so polluted that people cannot use the receding waters, or if there is a health hazard. So it is within this attitudinal setting which I hope is in the past, that it is encouraging to see emerge, a view of pollution control in terms of cost output equation, a view of pollution control which works towards process efficiency in industries, and a view of pollution control as a source of raw materials.

So here as well as in the international community, this challenge is being met by attempts to develop and apply "low-waste technologies" and residue utilization. It is only recently that this concept of residue utilization has been recognized as a component of waste management or pollution control policy. Because in the past the idea has been — you produce the waste and then you treat it, but now the emphasis is emerging that we should view the waste as a resource. The view is also emerging that waste recycling or re-utilization should be incorporated into the process that there should be an attempt to integrate the pollution control measures into the system rather than waiting for the waste to be produced and then trying to treat the waste. These are what we consider very hopeful measures that are emerging.

The UN Environment Program (UNEP) has a program on industry and environment which has documented case studies of companies like the 3M Company that has been able to reduce 70,000 tons of noxious gas and 500,000,000 tons of waste water and saving in the process some US$70,000,000 per year.Dow Chemicals, ICI and others have also been able to successfully retrieve pollutants to make profits. These examples illustrate that pollution control through waste re-utilization can become economical.

This concept of re-use of waste is also being done in Japan. As of April, 1979, we have some 23,000 firms using industrial wastes or, chanelling waste back and using it as a resource. Agriculture and agro-industry offer potentials for residue and waste utilization specially because of the quantity and volume of waste, and this was pointed out in Dr. Ouano's paper. Residue utilization programs would accomplish not only environmental and pollution control but also better management of resources which are being depleted by population pressure. It would also evoke more efficient techniques in processing, thereby increasing production. Dr. Ouano's paper illustrates and attempts to evolve a process or a technology that will do both: 1) reduce the waste water before it is discharged and in the process increase efficiency and increase the retrieval of the oil: 2) re-use the waste to generate a raw material. In this case he cites the example of using the palm oil waste for animal feeds.

Here in the Philippines, we are not too unfamiliar with the palm oil industry because we are familiar with some of the pollution effects of the coconut industry from the production of coconut and corn oil which we produce in large quantities. We are not unfamiliar with these processes. There are studies now also along the lines of Dr. Ouano's paper that attempt to introduce pollution-control technologies for existing plants. But I think the focus of Dr. Ouano's paper is more for new plants so that the pollution control measures can be incorporated into the operations and the process itself. And I think the main point that Dr. Ouano is trying to make in his paper is that we should not presume to consider that the waste needs to be produced. In his paper, he was able to point out that through solvent extraction and mechanical extraction, the waste water could be reduced to a very great extent preventing waste water from being dumped into the rivers and other waters.

One last point, I do not know whether there is already a decision on the palm oil industry, I had reservations on whether the Philippines would indeed become a major palm oil producing country, I feel that the support base in agricultural development would be evolutionary — very slow and also subject to world market prices. It becomes a very political and economic issue, because of its implications on our coconut industry — but I don't know whether that is part of the scope of our discussion this afternoon. However, if this decision has already been reached, as Dr. Ouano cited that so many hectares have already been planted to palm oil, I would just like to say that we hope that the suggestions presented by Dr. Ouano in his paper are seriously considered in order that we can incorporate the pollution control measures right into the early stages of the planning of the factory and the processes itself. We feel that this is one way, in fact, probably the only way at the moment that we can prevent the massive pollution effects which are being predicted by Dr. Ouano. I thank you.

Dr. Edwin Lee, Environmental Engineer, Discussant

First, I want to congratulate Dr. Ouano for his excellent paper. And second, to try to make a few comments on the paper itself. And with the time constraints I will make it as brief as possible. I do not want to focus on the technical aspects of his paper, because his paper stands pretty well by itself. As an innovative and technical approach to a very difficult pollution problem — a problem, as he had mentioned has boggled many countries that are presently in the palm oil business.

My remarks will be centered mainly on the concepts and approach that his paper so well present. The paper like that one is an excellent example what I call innovative approaches much needed today in pollution control technology. This requires the difficult task of innovative thinking and an alternative evaluation. However, I must report that today, many technicians and engineers in our field of pollution control limit the alternative evaluation only to the waste treatment process, and frequently avoid in-depth evaluation of alternatives in controlling waste within the industrial process itself. Dr. Ouano have brought us back to this basic fundamental so often overlooked by engineers in their singular approach in addressing solutions to waste water problems by only looking at treatment technology. This paper is a strong reminder to those of us working in the profession, to take a broader and more innovative approach to pollution control, that includes not only consideration for pre-plant processing of raw materials; in-plant processing of products; as well as post-plant treatment of wastewater and disposal processes and reclamation systems.

Only by this holistic and systematic approach can the total economics of pollution control and the industrial enterprises itself be evaluated and optimized effectively. We have been presented by Dr. Ouano of an example wherein the considerations for alternative to in-plant products processing, a very difficult pollution control problem, that have confronted the palm oil industry for many years can be solved. The proposal will not only solve a very difficult waste water treatment problem but it will also result in by-products that can be contributory to the income of the industry as well as benefit users of the by-products. These benefits from the by products will give cause for industry to view pollution control, not as annoying needs for compliance with regulatory agencies, but as income generation which also benefit the industry itself. In this case, industry would have no cause for fearing that pollution control requirements, would detract from the economic success of the enterprise itself. In a period of rising cost and increasing competition of trade and commerce, this broad approach which can have significant economic implications to the industry, is the approach that have long term implications to socioeconomic development programs of the nation and ultimately to the well-being of the people themselves.

This ultimate goal is the real objective of national development in which industries can play an important role, and engineers as well as industrialists, economic planners can more use the example that Dr. Ouano has presented, as a guide for other industries disposing problems.

Benedicto Adan, Discussant

When I read the paper of Dr. Ouano I find myself agreeing with what he said, hence I perhaps have very little things to say. But since I was invited here to say something so I have to strive to find words to comment on his paper, so without further preliminaries I would like to read what I have noted when I read the paper.

It is a common knowledge, particularly among pollution control specialists and industrialists, and also perhaps scientists like yourselves, that it is always expensive, if not very difficult to treat wastewater once it is generated. It is always better if wastewater can be tackled at its source by modifying the process and that is the suggestion here of Dr. Ouano, thereby eliminating discharges without affecting the quality of the final product — should treatment be undertaken. However, because of lapses of some of the industrialists, the resources expended for controlling pollution become a very significant loss to the industry. This loss is reflected ultimately on the higher price of the product. In a competitive economy like ours, this could mean loss of market, which our developing country or any other country for that matter can ill-afford. It is incumbent on industry therefore to seek means by which material losses are reduced and consequently, the cost of pollution control is reduced correspondingly. In achieving this goal the product remains competitive in the market and the industry prospers. It is also a common knowledge that industry is reluctant to invest in an innovative process and even more reluctant in investing in pollution control, that is an experience. For the money invested in controlling pollution brings no return. Industry may be induced to invest resources, nevertheless if the change brings material benefits to the industry or the regulatory agencies like NPCC obliges the industry to do so. This might be effected thru imposition of stiff effluent charges or fines or even closures. These prospects will certainly induce industries to review its processes to cope with water quality and effluent standards of the regulation authority. It should be worth mentioning therefore, that there is no reason to believe that rules and regulations will not be more stringent in the future, in view of the government's thrust on industrialization.

To lift the country's economy at this very early period of the palm industry, proponents under the regulatory agencies should take stock, seriously review the future outlook to cope with the problems that may eventuate. One will look at the suggested solution in the paper to induce more efficiency in the oil extraction process. In the case under study the wastewater from the palm oil industry has been characterized to be a very strong, and stable wastewater. It is very high in BOD, as explained by Dr. Ouano and very low in pH. It has been also reported that some elements such as cadmium, iron, copper and manganese were found in the wastewater in appreciable concentrations. The very high organic matter content of the wastewater when subject to a very efficient secondary treatment process, the process could not reduce the organic content to acceptable limits and therefore, it should not be discharged into the environment. The very low pH requires a great quantity of chemicals for neutralization — all of these of course cost money.

The approach suggested by Dr. Ouano found to be quite attractive, as the process changed other known and tried methods which industry can avail of: i) water conservation and (2) wastewater string reduction. Description of these methods abounds in literature and have been explained already. And string water levels which could be managed by the conventional wastewater treatment processes in addition to the recovery and re-use of the reusable fractions of the wastewater which otherwise would have been gone with the plant effluent to be classified as waste and therefore a lost material. The conventional waste process mentioned in the paper and is a universal application in Malaysia, Thailand and other countries which produce palm oil, generates very strong wastewater as had already been stated. And this was found to be the major cause of gross wastewater pollution in places where the palm oil industry is established. The pollution from this source has reached a point already that expansion of palm tree plantation or the start of a new plantation is not being encouraged. For the industry to survive a very careful review of the oil extraction process to minimize material wastage, and the method of wastewater treatment is very imperative. Studies have been undertaken to remedy the situation. One of the studies have been mentioned in the paper and it proposes to change the process at one from the production stages from wet to dry by replacing steam with the hot air at the sterilization stage of the extraction process. It is in this stage of the process where most of the wastewater is generated. This suggested process modification had not been applied on a full scale but pilot scale studies according to Dr. Ouano, indicates its high potential for coping with the problem of wastewater and pollution control.

Recently, a report states that hot air is in use at the Dulson Durian oil mill in Malaysia to separate the fiber from the nuts, and the broken shell from the kernel. It had been reported also that hot air application, in addition to the other advantages already mentioned in the paper tends to reduce the moisture content of the nuts, facilitating the cracking process. Experience has shown also that it takes time before results of experimentation find their acceptance and hence, their application. Moreover, the suggested process change although seemingly attractive and superficially uncomplicated may cause problems in subsequent process operations.

Additionally, the proposed process change may require considerable study and testing at an early start is therefore advised. First, to iron out kinks during trial runs. Second, to afford longer period for personal training.

The selection of the subject for discussion in this 4th Annual Scientific Meeting of the National Academy of Science and Technology is indeed most fortunate. First, the palm oil industry in the Philippines is needed and just taking off the ground so to speak.

This is relevant at this point in time, therefore to assist the potential of this new industry in the Philippines for its contribution to the worsening pollution of the waters of the country.

Second, it delivers clear and loud a message, to decision makers to initiate the review of its staunch stand on oil processing methods and wastewater treatment processes employed by the industry and similar industries today with a view to adopting a process system or systems with the attributes of minimizing material losses and subsequently reducing the volume and strength of waste to be managed.

Third, some scientists in this audience or the NAST itself, may find the problem challenging and worthy of support to initiate, perhaps and carry out researches in this regard. Since there are no palm trees or nuts at present to process in the Philippines nor waste from the industry to treat, the researcher made them first in literature collections and reviews and/or conduct experimentation on the treatment of desiccated coconut waste — this had been mentioned, which has similar characteristics as the palm oil in wastewater in terms of BOD, and low levels of pH values. This latter suggestion is wastewater treatment and not a process change. The literature research uncovers a method by which wastage of material can be minimized so that in the end the goal of pollution control is achieved. Thank you.