PIG WASTE MANAGEMENT & POLLUTION CONTROL: *IDEAS FOR MEXICO*

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Prolegomena

As I was driving the other day thinking about what I should write in this paper for my friends and colleagues in Mexico, a sticker in the car in front of me caught my attention; the sticker said: "THINK GLOBALLY, ACT LOCALLY". Ever since then, I have been thinking that the theme of my presentation should be "Think Globally; Act Locally".

Not knowing the exact topics that would be of most interest to you, I thought perhaps it would be appropriate for my written paper, at least, to give you an overall view of the global issues as I see them, before going into technical matters that might be used to help you develop appropriate policies for the conditions of swine production in Mexico.

I was the first agricultural engineer to receive in 1963 a doctoral degree in sanitary engineering, before environmental pollution became a hot public issue. Since 1963, I have had the opportunity to visit and work in over forty countries around the globe and to watch the growth of environmental legislation and public awareness. All of the tables and technical data presented here were extracted from my book "Pig Waste Management and Recycling: The Singapore Experience" to be released in 1992 by the International Research & Development Center, Ottawa, Canada, which focuses on warm climates, and in my first book "Animal Wastes" that was published by Elsevier Applied Sciences in 1977, and which focused on cold climates.

INTRODUCTION

The problems associated with pig wastes are a result of the growth in pig population, of the recent trends in large intensive commercial pig production without access to sufficient cropland, the limitations of the waste management technologies, and of the environmental impact of livestock production on both the global and local environment.

Pig Population Trends

Based on global statistics compiled by FAO [see Table 1], the standing pig population [SPP = all live pigs, sows, boars, piglets, porkers, and gilts; the average weight of all live pigs on a farrow to finish farm is 50 kg/SPP] increased from about 500,000 SPP in 1965 to almost 800,000 SPP in 1985.

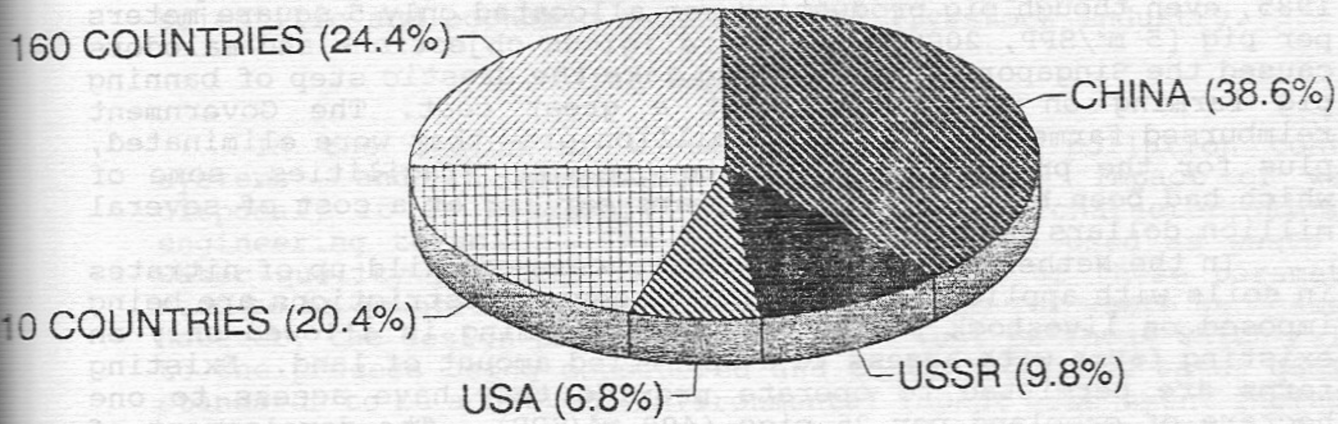
Asia accounted for 48% of the world's SPP and was the region with the largest annual growth rate (4.7% versus 3% per year for the rest of the world). The countries with the biggest annual growth rates were Netherlands (9.9%), Spain (9.2%), Japan (7.6%), Romania (7.3%), East Germany (7.3%), Mexico (5.4%), followed by China (5.1%). The only country with negative growth was USA.

Table 1
STANDING PIG POPULATION (SPP) IN THE WORLD IN 1965 AND 1985

Regions and Countries	Standing Pig Population in Thousands				Growth	
	SPP 1965	% of Total	SPP 1985	% of Total	Total %	Annual %/Year
CONTINENTS						
Asia and the Pacific	195350	39	379870	48	+ 94	4.7
Europe (Including USSR)	170980	35	2577[illegible]0	32	+ 51	2.5
North America (Including Mexico)	72120	15	83750	11	+ 16	0.8
South America	48740	10	59500	7	+ 22	1.1
Africa	5980	1	10780	1	+ 80	4.4
Oceania	2400	<1	3030	<1	+ 26	1.3
World Total SPP	495570		794700		+ 60	3.0
WARM / TROPICAL REGIONS						
Asia and the Pacific (Excludes 30% of SPP of China & 100% of Japan)	149570	30	284620	36	+ 90	4.5
Europe	-	-	-	-	-	-
North America (30% of USA & All of Mexico)	27700	6	35180	4	+ 27	1.4
South America (Excludes Argentina, Peru & Chile)	42020	8	52450	7	+ 25	1.2
Africa (Excludes S. Africa)	4580	1	9350	1	+104	5.2
Oceania (50% of Australia & New Zealand)	1200	<1	510	<1	+ 26	1.3
Sub Total SPP	225070	45	383110	48	+70	3.5

About 48% of the SPP is located within warm climates (Table 1). Out of the 172 countries and territories which grow pigs, 13 countries had a SPP of more than 10 million and accounted for 75% of the world's pig population (Fig 1).

Figure 1
COUNTRIES WHICH PRODUCE MOST OF THE PIGS IN THE WORLD



Environmental Constraints to Pig Production

Aside from economic considerations, what was constraining and will continue to limit the development of the pig industry in both the temperate zones and the tropical belt is the environmental impact of pig farming There are three features of pig farming which have negative impact: (a) water pollution from pig wastes, (b) malodors emanating from pig farms, and (c) religious sensitivities to pigs.

Environmental concerns are restricting many countries wanting to expand their pig production. The limitations imposed differ from country to country, but these limitations are being implemented in almost all countries of the world.

In Singapore, where commercial farming thrived from 1970 to 1985, even though pig production was allocated only 5 square meters per pig [5 m^2/SPP, 2000 SPP/ha], religious objections and malodors caused the Singapore Government to take the drastic step of banning pig farming on the Republic at a great cost. The Government reimbursed farmers for the half million pigs that were eliminated, plus for the production and waste treatment facilities, some of which had been built only three years earlier at a cost of several million dollars per farm.

In the Netherlands, because of concern of build-up of nitrates in soils with applications of manure, severe restrictions are being imposed on livestock production. Pig farming is allowed only on existing farms with access to a specified amount of land. Existing farms are permitted to operate provide they have access to one hectare of cropland per 25 pigs (400 m^2/SPP). The development of new pig farms was halted in 1985, in Netherlands.

In Northern Europe, the spreading of pig manure on land is forbidden for 4 to 6 months during the Autumn and Winter months. Even during the growing season, the rate of manure application from pig farms is strictly regulated. Therefore, farmers are required to store liquid manure, in environmentally acceptable above ground storage tanks, for almost half a year.

In Malaysia, where the state religion is Islam, and the pork consuming population is less than 50%, pig farming is being restricted to sites zoned for pig production, and standards of zero waste discharge are being considered because of religious objections to pigs. In Hong Kong, there is no religious problems, but the environment protection agencies is requiring even small pig farms to install treatment plants to meet effluent quality standards of 50/50 mg/L BOD/TSS [Biochemical Oxygen Demand/ Total Suspended Solids], just like sewage treatment works for the municipalities. Pig farming in Malaysia and Hong Kong, even though each for its own reasons, has a precarious future.

Environmental Pollution

The contribution of livestock production, in general, and pig rearing, in particular, to Global Warming, [a topic that was the main theme of the recently held Environmental Summit in Rio de Janeiro, Brazil], through the release of methane and ammonia gases to the atmosphere are under scientific scrutiny by governmental agencies and environmental groups. Such studies may result in severe restrictions to pig production in the long run.

Therefore, if any of you think that you, or the farmers you advise, can go on raising pigs without any concern with the environmental impact of pig wastes, then the future of the pig industry in Mexico will be a bleak one. Managing the environmental impact of pig production must receive the highest priority of the scientific and economic sector of the livestock industry.

PIG WASTE PROPERTIES

In the design of waste management and pollution control systems and in assessing the environmental impact of waste disposal, it is necessary to quantify waste characteristics in engineering terms. The terms which may be used as waste and water quality parameters are many. Not all of these parameters need to be quantified before devising systems for waste management. However, the design parameters selected must be those which relate to the process being considered and to the effluent water quality standards to be achieved. Environmental impact assessment includes, besides the effects of wastes on water and soil resources, nuisance factors plus social and political considerations that cannot always be quantified.

Pig Waste production Rates

Since a pig eats more as it increases in weight, the waste generated is proportional to the live weight of the pig.

The liquids and solids generated depend on the type of diet, collection system, weather conditions and management practices. Generally, 10 to 20 liters of water are used in tropical climates per pig [10-20 L/SPP or 20-40 L/APU; 1 APU = 2 SPP]. In North Carolina and in some of other states where commercial pig production is highly developed, pig pens are flushed with water almost constantly, generating large quantities of waste water [100 to 200 L per pig per day] that is extremely low in solids concentrations.

Table 1 gives typical characteristics of wastes as generated. The nitrogen content of pig wastes varies from 32 to 50 grams per 100 - kg live weight pig [APU]. Table 1 may be used to calculate the quantities of pollution generated. To determine, for example, the quantities of BOD generated on a farm in Mexico, multiply the number of sows by 10 to approximate the number of standing pigs [10 SPP per sow], then multiply the SPP number by 50 kg/SPP to get the total live weight of the pig population, and then divide the live weight by 100 to approximate the animal population equivalent [APU] and use Table 1 to calculate the quantities of the various waste parameters.

Table 1
PIG WASTE DESIGN PARAMETERS FOR WARM AND COLD CLIMATES

Waste & Wastewater Parameter			Singapore* Mean	Malaysia * Mean	Malaysia * 80%*	ASAE** Mean	Taiganides*** Mean
Feces + Urine)	(TWW)	kg/APU*d	8.4	6.9		5.5	6.9
Total Solids	(TTS)	g/APU*d	840	690	810	550	690
Total Volatile Solids	(TVS)	g/APU*d	670	540	630	440	570
Total Suspended Sol ds	(TSS)	g/APU*d	690	560	660	---	---
Chemical Oxygen Demand	(COD)	g/APU*d	840	660	790	510	710
Biochemical Oxygen Demand	(BOD)	g/APU*d	250	270	320	180	220
Total Kjeldahl Nitrogen	(TKN)	g/APU*d	50	32	41	41	39

*Source: S S Teoh, E P Taiganides & T C Yap (1988). Engineering design parameters of wastes from pig farms in Malaysia. Biological Wastes, 24: 95-104. Note: the 80% value was equalled or exceeded 20% of the time ** Source: ASAE (1983). Manure production and characteristics. Agricultural Engineers Yearbook of Standards, D384. ASAE, St Joseph Michigan, USA. *** Taiganides, E P (1977). Bio-engineering properties of feedlot wastes. In: Animal Wastes. E P Taiganides, (Ed), Elsevier Applied Sciences, London.

For example, a farm with 600 sows, will have a pig population of approximately 6000 SPP, a total live weight of 50*6000 = 300,000 kg, or 3,000 APU [300000/100]. At 250 g BOD/APU, the total BOD generated will be 250 g * 3000 = 750,000 grams or 750 kg.

If 40 L/APU were used to clean and flush the the 8.4 kg of feces and urine per APU, the concentration of the BOD will be 250 grams BOD per 48.4 litters of wastewater or 5165 mg/L [250*1000/48.4].

Based on a a BOD pollution population equivalent of 2.5 humans per pig, the water pollution potential of pigs is equivalent to more than 2 billion humans or 40% of the human population of the world. For the 600 sow Mexican farm of the example above, the pollution potential from the farm would be equivalent to the BOD of a town with 15,000 people.

"Think Globally; Act Locally"

GENERAL APPROACH TO PIG WASTE MANAGEMENT

The objectives of a good waste management system should be: (a) Provide a clean and healthy environment for the pigs; (b) Eliminate noxious odors and gases in the pig houses; (c) Reduce or eliminate manual labor in pen cleaning and waste handling; (d) Reduce the amount of pollutants discharged from the farm to the environment.

The objective of removing pollutive nutrients from pig wastes can best be met with treatment of the wastes.

Removal of BOD, COD , nitrogen, phosphorus and other nutrients from pig wastes and wastewaters can be accomplished physically, chemically biologically, and a combination thereof. Removal by chemical treatment is costly and not practical. Biological removal requires a series of treatments, some of which are mechanical. The most practical method is removal of fresh solids from the liquid manure slurries before the nutrients such as nitrogen dissolve in the water of the manure slurry.

Manure slurries consist of water and solids. The water is in the form of free water and bonded water. The free water is the portion of water in the manure mixture that flows out. The bonded water is the water tied up with the solids. Solids are either suspended or diluted in a pig waste slurry.

Since a major part of the nutrients are with the solids, separation of the fresh solids from the manure slurry is the best way to reduce the amount of nutrients in pig wastes. The best method of solids separation produces solids with low moisture content, and liquids with only very small particles in it.

Sedimentation, stationary and moving screens can only remove some of the free water and none of the bonded water. Moreover, these methods are only effective with extremely diluted wastes, which complicates the problem.

The screw press separation is the best method to accomplish solids separation because it squeezes out all of the free water plus some of the bonded water.

The effluent from mechanical solids separation is best because the resulting liquid that can be pumped with customary wastewater pumps instead of the expensive chopper pumps.

Also the liquid effluent contains only small particles that remain in suspension and thus are easily decomposed biologically by bacteria to reduce the pollutant concentrations, minimize odor nuisance during storage, and maximize nutrient availability when applied to land.

Furthermore, the liquid effluent can be pumped with high pressure pumps through long pipes and sprinkler guns without creating plugging problems in the waste network.

There are screens that achieve a moisture content of 80 to

75%, but because screens do not squeeze out all the free water, water remains in the separated solids, leaks out when being transported in lorries, creates sanitation, odor and other nuisance problems.

Separated solids whose water has been squeezed out with the screw press action have the optimal moisture content for long term storage plus a particle structure honeycombed with air pockets that stimulate composting.

The solids separated with a screw press separator have the optimum moisture content, texture and solids structure to enable excellent air movement for composting to take place aerobically with minimum odor nuisance. The solids are not attractive to flies, rats and other vermin.

High temperatures in the windrow piles of the separated solids kill pathogens and dehydrate the solids, volatilize ammonia nitrogen into the air, making recycling of the solids possible.

Solids separated can be used as plant and soil amendments; as bedding material; are mixed with feed ingredients to produce rations for ruminants animals; are granulated, bagged and sold as commercial compost.

Removal of nitrogen, phosphorus, potash, and other nutrients by solids separation with a screw press ranges from 25% to as high as 80%. Losses of nitrogen from aerobic and anaerobic bacterial treatment can be made to amount to as high as 70% of the original content. Phosphorus can be separated in biological treatment, but cannot be lost. Both fungal and algal fermentation can remove high quantities of nitrogen and phosphorus, but the current technologies are not practical on pig farms.

Prevention can go a long way to solve the problem. Research should focus on modifying the feed ration formulations so as to minimize the amount of nitrogen and phosphorus that enters the waste stream, in the first place. Both nitrogen and phosphorus are essential elements in feed rations, but they also cause environmental pollution.

Protection of the environment demands that the colossal quantities of manure in today's intensive pig farms be managed with ecologically sound systems that utilize innovative technologies.

Manure disposal now is an acute problem that is restricting the growth of the pig industry, and is coming under strict governmental regulation.

The solution to pollution is not dilution. The solution is innovative technologies to remove the pollutants before disposing of the pig wastes into the public environment.

"Think Globally; Act Locally"

UNIT TREATMENT PROCESSES

There are many processes available for achieving the proposed treatment objectives, with each process having its own advantages and disadvantages that may restrict its application.

Anaerobic Lagoon

Anaerobic lagoons are are deep, 5 meters or more. The entire depth of the liquid is devoid of oxygen, except for an extremely thin surface layer. In the absence of oxygen, anaerobic bacteria serially breakdown the wastes to form methane, carbon dioxide and other gases. Two of the malodorous gases generated are hydrogen sulphide and ammonia which give anaerobic lagoons their typical objectionable odor, especially during calm, hot humid weathers. Odors can be reduced by lower loading rates and also maintaining constant water levels without fluctuation and turbulence.

Anaerobic lagoons have the advantage of requiring little land area. However, odor is a persistent disadvantage.

My suggested design for the organic loading rate of anaerobic lagoons for Northern Mexico is 0.12, and for tropical Mexico is 0.20 kg TVS /m^3*d [TVS = total volatile solids per cubic meter per day]. Using the design values for TVS of Table 1 for the 600 sow farm of the example above, the volume of the lagoon in the tropical part of Mexico would be 2.85 m^3/APU or 8,550 m^3 for the entire farm.

Modified Anaerobic Lagoon

Such lagoons have an anaerobic layer at the bottom where suspended solids settle out and are digested by anaerobic organisms. The surface zone is kept aerobic by providing floating aerators. This surface aerated zone, rich in oxygen, will oxidize odors from the deeper portion thus reducing odors from the lagoon. The products of anaerobic digestion will provide nutrients for the anaerobic organisms at the surface.

Surface aeration in such lagoon therefore control odors but increases the capital and operating costs compared to a simple anaerobic lagoon. The level of treatment is also 85-90% reduction in BOD and effluent quality without further treatment is in the range of 300-500 mg BOD/L. Such lagoon can be combined with a flushing system to provide a low cost treatment and water recycling system.

Aerated Lagoons

An aerated lagoon is a basin of 2-4 m depth in which oxygenation is accomplished by mechanical or diffused aeration units and by induced surface aeration. The turbulence level maintained in the basin ensures distribution of oxygen throughout the basin but is usually insufficient to maintain solids in suspension. As a result most inert solids and non-oxidized biological solids settle to the bottom of the basin where they undergo anaerobic decomposition.

The effluent from aerated lagoon will have more suspended solids than from the anaerobic lagoon. Incorporation of a settling basin in the lagoon design will yield a clarified effluent which is better in characteristic compared to anaerobic/ modified anaerobic lagoons. However the high energy cost required for aeration makes it economically unattractive.

Oxidation Ditch

The oxidation ditch process is a modified form of the activated-sludge process with BOD removals of 90 to 97%.

Unlike the conventional activated sludge system, the screened raw waste enters directly into the aeration basin instead of flowing through primary clarifiers. The aeration equipment is in the form of rotor aerators which extends across the width of the ditch. The rotors furnishes the necessary oxygen and keeps the liquid waste mixed and moving through the ditch at fairly high pace (30-35 cm/sec). An oxidation ditch can also be built into the pits under slatted floor to further economize on land use.

The vigorous mixing required to inject oxygen into the liquid demands high inputs of energy, thus making the process expensive.

Anaerobic Digestion

Anaerobic digestion is widely used to stabilize concentrated organic wastes. The waste is contained in a sealed vessel and oxygen is excluded. Under these conditions, anaerobic bacteria thrive, converting up to 90% of the degradable organic into methane and carbon dioxide (CH_4:CO_2 is usually 65:30).

The high degree of organic destruction coupled with slow growth rate of methane-forming bacteria result in the production of little sludge which is highly mineralized and thus easy to dewater. Power costs are reduced because oxygen is not required. In addition the methane gas can be recovered as a source of energy for heating or for the generation of electricity. This will cut down the power cost but will increase the capital expenditure. Anaerobic digester require careful supervision to remain operational.

Anaerobic digester produce combustible methane gas (900 kcal/pig.day, equivalent to 0.7 kwhr/d) highly mineralized and easy to dewater digested sludge and digester supernatant. They can achieve 80% reduction in BOD of the influent. However the supernatant still contains soluble organics that require extensive treatments before discharge into a public waterway.

Selection Factors for Treatment Methods

Besides the cost-effectiveness of a treatment system other selection factors have to be considered: (a) performance; (b) inputs; (c) outputs; (d) implementation time.

The appropriate system should have a good cost effectiveness, i.e., lowest cost for a desired level of performance (measured as % BOD removal etc). It should also be a stable system capable of withstanding fluctuations in the incoming wastewater load. It should not be too sensitive to equipment malfunctions. Another performance factor of importance is odor production. Hence, anaerobic lagoons that produce malodors are not suitable near urban areas; modified anaerobic lagoons with much reduced odor production are a viable alternative in such cases.

The nature of inputs should be considered, also. Systems requiring lower capital input but needing high operating costs could in the long term cost more per pig marketed than an alternative requiring more capital but lower operating cost e.g., activated sludge with anaerobic digestion for energy recovery. In addition manpower and the level of expertise required to operate the system must be low, especially if small on-farm plants are to be used.

Outputs factors which need to be considered include quantity and nature of solids generated by the selected processes. Hence systems with long detention time, eg modified anaerobic lagoon, that produce less solids of very stable nature, are preferred over aerated lagoons that generate more solids.

Implementation time is related to the complexity of the treatment process. More complex and advanced system usually take many years to built.

The organic nature of pig wastes make it highly polluting but at the same time treatable by a variety of biological processes that can yield resources such as water for reuse in flushing and energy.

In the immediate future, it will be necessary for all pig farms to adopt either on-farm treatment methods or to cooperate with one another to develop collective pig waste treatment plants. Only by such action can the farming community prevent further restrictive environmental regulations that would drastically curtail pig production in Mexico.

MODULAR WASTE TREATMENT

I am proposing a modular waste treatment concept for pig farms in Mexico that is designed to meet the following three objectives:
(1) Reduce gross pollution discharges from pig farms;
(2) Improve environmental sanitation on the farm;
(3) Enhance quality of the environment in the farm surroundings.

Although from the standpoint of ecology, it is best if all three objectives were to be met from the very beginning, from the standpoint of cost effectiveness and practicality, it is better to design a step-wise compliance schedule so as to allow time for farmers to acclimatize themselves to the idea, revamp their operational procedures to accommodate the new work load in running a treatment plant, and develop the necessary attitude and skills needed to operate biological processes, and to absorb the added cost of waste treatment without creating severe cash flow problems.

The modular pigwaste treatment system is designed to allow time for the farmer to learn and adjust.

Treatment Modules

The modules for the three treatment objectives stated above are:
(1) SST: Solids Stabilization Treatment technology
(2) MPT: Most Practical Treatment technology
(3) BDT: Best Demonstrated Treatment technology

SST

The primary module of the Solids Stabilization Treatment Technology [SST} consists of deep anaerobic lagoon, and sludge drying beds. The organic loading rates for Mexico were given above, but it is best to also check with local authorities for guidance on this and other unit operations. Suffice to say that the SST module can achieve 80 to 90% reduction of gross pollution from the farm. However, SST will not reduce and may even aggravate pig farm malodors.

A major advantage of this module is that it has very low cash operating costs. Because no energy consuming equipment are involved, the farmer is not burdened with high utility payments soon after the capital investments. Also lagoon and sand filter bed construction is simple and relatively inexpensive. Thirdly, the other modules can be added without any major alterations or difficulties.

It is worth noting at this juncture that the BOD of the effluent from the SST Module was expected to be about 10 grams per standing pig population (10 g BOD/SPP.d) per day which when diluted to human sewage of 200 L per person per day was equivalent to 50 mg/L sewage BOD, thus could meet most mass emission rate standards.

MPT

The secondary objective of pig waste treatment can be met with the Most Practical Treatment Technology [MPT] module. MPT involves the installation of surface aerators to oxygenate the upper 2 m of the anaerobic lagoon. This modification of the anaerobic lagoon results in what is termed the aerated anaerobic lagoon . Moreover, the lagoon supernatant is pumped into a clarifier for the removal of suspended solids (TSS) which can be enhanced, if necessary, with the addition of coagulating chemicals. The surface aerators moderate malodors and aid TSS removal thus achieving high effluent quality standards.

MPT can achieve 95% pollutant reduction. The expected effluent could have a BOD of around 5 g BOD/SPP.d which when diluted at 20 L/SPP, the volume of water used on the farm, gives a BOD concentration of 250 mg/L, but which, is equivalent to 25 mg/L sewage BOD.

BDT.

The tertiary treatment objective can be met by what is termed the Best Demonstrated Treatment Technology [BDT] which is accomplished by upgrading MPT with the addition of an extended aeration unit. The extended aeration would facilitate higher BOD reductions and better TSS removal through the production of settleable bacterial flocs. The BDT would yield an effluent of 1 g BOD/SPP*d which is equivalent to 98-99% reduction of pollution and an effluent BOD of 50 mg/L which would be equivalent to 5 mg/L sewage BOD.

MET

Most economical treatment technology (MET) is between MPT & BDT in that it meets strict effluent liquid standards but does not include energy recovery through digestion.

CONCLUSIONS

I hope you too have reached the conclusion that if we are to resolve the environmental problems, we must think of the global implications, but act to take care of the local environmental impact. Unless, the swine farmers of Mexico clean up their act by taking the initiative to develop and implement some form of waste containment and pollution control, much stricter standards will be imposed by regulatory agencies that may affect the economic viability of the pig industry. I have outlined, some general approaches that hopefully will help you in your efforts to advise the farmers on the proper approach to the environmental challenges facing the industry.

Table 2
UNIT PROCESSES IN MODULES OF TREATMENT

Treatment Module		SST	MPT	BDT	MET
Treatment Objective		3 Units	SST + 3	MPT + 4	MPT + 1
BOD Reduction	90%	Anaerobic Lagoon	Anaerobic Lagoon	Anaerobic Lagoon	Anaerobic Lagoon
" "	95%	----------	Surface Aeration	Surface Aeration	Surface Aeration
" "	95%	----------	Clarification	Clarification	Clarification
" "	97%	-------------	Coagulation	Coagulation	Coagulation
" "	99%	--------------	--------------	Oxidation Ditch	Oxidation Ditch (Surface Aeration)
TVS Reduction	40%	Lower Part of Lagoon	Lower Part of Lagoon	Lower Part of Lagoon	Lower Part of Lagoon
" "	50%	------------------	------------------	Digestion	------------
"	60%	------------------	------------------	Sedimentation	------------
" "	60%	------------------	------------------	Equalization Tank	------------
TTS Concentration	20%	Filter Beds	Filter Beds	Filter Beds	Filter Beds
" "	60%	Composting	Composting	Composting	Composting
COST RATIOS FOR UNIT TREATMENTS					
Construction Cost Ratios		1.00	1.42	4.60	2.29
Overhead/Infrastructure/Site Clearance		1.00	1.00	1.00	1.00
Paving, Fencing, Landscaping		1.00	1.00	1.62	1.00
Engineering Survey, Design, Commissioning		1.00	3.22	1.61	
Contractor Services and Miscellaneous			2.00	1.00	
Total Initial Investment Cost ratio		1.00	1.38	2.09	1.91

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I would like to thank the Organizing Committee for honoring me by inviting me to address this august body of scientists and professionals who advise the pig industry Mexico, and for the opportunity to get acquainted with the exciting projects that are being implemented for the free trade agreement between Mexico, USA and Canada.