Proceedings of the International Conference for Agricultural Machinery & Process Engineering
October 19-22, 1993, Seoul, Korea

G. GIAMETTA - G. ZIMBALATTI

Institute of Agricultural Engineering
University of Reggio Calabria
Piazza S. Francesco, 89061 Gallina di
Reggio Calabria, Italy.

DISPOSAL OF AGRICULTURAL SEWAGE BY MEANS OF EVAPORATING PANELS

ABSTRACT

The purification of sewage deriving from agricultural and food industries is today a serious problem mainly in areas characterized by intensive production plants.

The solution examined in this work, involves a system of natural evaporation which employs special panels with a large evaporating surface constitued by an internal cellular structure in polyethilene. Using renewable energy they allow to speed up the natural evaporating effect thus eliminating some drawbacks such as swamps and obtaining sewage concentration with relatively low costs.

The Institute of Agricultural Engineering has carried out tests on the disposal of sewage deriving from two very important production sectors: pig-breeding and olive oil production. Data were gathered in order to verify the operating capacity of plants and their output capacity mainly as a function of weather variables. On the remaining concentrated part tests were also carried out in order to know its chemical and chemical-physical features and to study the possibilities for its use.

Key Word: Sewage, Renewable energy, Evaporating panel.

INTRODUCTION

In the last few years a lot of studies and investigations about the purification of sewage deriving from farms and food industries have been carried out because of the increasingly demanding environment requirements. This accounts, indeed, for a serious problem from both an environmental and an economic point of view mainly in areas characterized by intensive production plants with an industrial rather than farming-related approach.

This paper envisages a solution involving a system of natural evaporation by means of special panels having a large evaporating surface. They use renewable energy and can speed up the natural evaporating effect thus eliminating some drawbacks such as swamps and obtaining sewage concentration with relatively low costs.

The tests carried out by the Institute of Agricultural Engineering mainly concerned the disposal of sewage from two very important production sectors: pig-breeding and olive oil-production.

As regards the former, the problem is of crucial importance in Europe. Presently with more than 100 million pigs grown, Europe keeps the second place in the world behind China (331 million) and before URSS (77 million) on average 48 pigs/km^2 are observed.

Examining the content of the nutritional elements of pig dung (table 1) it comes out that it can be better used in agronomy.

In areas with a greater production intensity, however, the disposal of large quantities of dung turns out to be rather difficult since the unlimited spreading of sewage on the soil is unconceivable on account of agronomic problems, legislative restraints and environment protection. Discharge of sewage into surface water or public drains are alternatives to spreading on the soil.

As to discharge of sewage into surface water the breeding farm must be provided with a purification plant in accordance with the regulations of the law in force. A number of unfavourable factors (inadeguate treatment lines, lack of skilled personnel, large amounts of money to be invested, inaccurate results) discourage, however, the installation of these plants "Bonazzi G. and Martini P.(1987)".

On the other hand discharge into public drains is used rather rarely by civil breedings since spreading of sewage on the soil is less expensive. Furthermore, sewage from production breedings requires more of less complicated, treatments to be performed on the spot.

This entails, of course, additional costs which add to those necessary for using the public purification system.

The problem of waste water from olive oil production mainly concerns the Mediterranean area, especially Spain and Italy.

Besides the high costs of production and a strong competition by other oil-pruducing countries, oil sector is encumbered with the need to reduce considerably waste from oil milling. Presently oil waste, though having a high content in organic matter, is scarcely biodegradable due to the presence of organic substances, wich cannot be oxidized biologically, as well as biotoxic substances such as polyphenols.

The tests reported in this paper were carried out to try to solve these problems. Data were gathered in order to determine the operating capacity of the plants of sewage disposal and their production capacity, mainly as a function of weather variables.

Moreover the final concentrated residues were also analyzed in order to determine their chemical, and physical features and to investigate the possibility for their use.

MATERIALS AND METHODS

The system for sewage disposal used in both cases consists of evaporating panels; the type of sewage and the kind of farm organization determine, of course, differences in the types of plants used. The quantity of sewage deriving from pig-breeding is equal to about 13 to 15 m^3/day and result from the dung of the animals, the water used for removing it and rain water falling onto open areas of shelters. The system of excrement removal it provided with dumping tanks; these flush out at regular intervals along the defecation lanes from which sewage flows into a collecting vat, thanks to a slight slope.

The plant of sewage disposal consists of the following units (fig. 1):

- the collecting tank, provided with a shaker, into which both sewage just so and concentrated sewage from the evaporator tank run; it has a capacity of about 20 m^3;
- the centrifuge, which separates most solid part of sewage;
- the storage tank, where the watery part of sewage is stored; it is lined with elastomer and has a capacity of about 3000 m^3;
- the evaporator, which consists of 7 groups of two panels each. Every panel is provided with a spreading nozzle;
- the evaporator tank, for recovering by gravity the surplus of sewage falling from the evaporator;
- a serios (15) of air-driven valves: 14 valves convey sewage to the nozzles while the other one sends concentrated sewage to the collecting tank;
- three motor-driven pumps provided with float lever controllers;
- control board;
- air compressor for driving valves.

The centrifugal separator (18.5 kW at the beginning and about 7 kW during operation) generally does not work for more than eight hours a day. The 1 kW motor-driven pump which feeds it (P1) has a variable capacity depending on the percentage of the solid part of sewage. The float lever controllers regulating the electropump (P1) are located in the collecting tank.

The storage tank with its large area has a further evaporating effect which adds to that ensured by the evaporator itself. This is of great importance mainly in periods when the evaporating unit does not work efficiently because of absence of wind, high humidity in the air and so on. The tank also collects the rain water since it is not covered. The storage tank periodically conveys part of its content into the evaporator tank by means of a 1 kW motor-driven pump (P2) whose float lever controllers are located in the tank itself.

The evaporating panels, each being 2 m x 3.5 m in size and having a thickness of 0.4 m, are made of high density polyethilene. They have an internal cellular structure in the longitudinal direction. The channels have a shape and section which ensure a large enough wet area (600 m^2) in so far as the need to avoid clogs allows.

Each panel has a vertical pipe in the middle which ends with a nozzle for spreading sewage on it. The inclination of the panels (30° with respect to the vertical line) allows them to occupy a very limited space and ensures a rather uniform spreading as well as a large area struck by the wind. Panels, of course, are orientated in the horizontal plane perpendicularly to the direction of the prevailing types of wind. The 14 nozzles are cyclically fed (12 s each) by means of a 1 kW (P3) motor-driven pump and a series of air-driven valves. At regular intervals a cycle counter causes the fifteenth valve to open; the evaporator tank then unloads its content into the collecting tank. In theory this should occur when the content of the evaporator tank has reduced to such a quantity that the solid portion has increased to a value equal to that of sewage. This operation is requlated by the minimum level float which is placed in the evaporator tank.

As to the plant of disposal of vegetation water, installated at an oil-mill where olives were processed by a traditional system (discontinuous process by pressing), it had a different size (2 groups of evaporating panels) compared with that described before. Unlike that, it lacked a centrifugal separator but was provided with a tank for storing the final concentrated residue. All the other units of the plants, although placed differently and sized proportionally, had operating features similar to the plant described above.

RESULTS

The residual product of the plant of disposal of sewage from pig-breeding only consists of the solid part deriving from centrifugation.

The tests performed showed that the centrifuge can treat up to 5 m^3/h of sewage, separating about 80% of the solid portion during each phase. The analyses carried out in a specialized laboratory trough the methods used for compost and sludges (IRSA CNR) allowed to obtain the data reported in table 2. In view of a probable utilization of the solid part, tests are being carried out in an earthworm breeding.

The clarified part runs into the storage tank with a total capacity of 35 m^3/day, including the regeneration.

As far as the capacity of sewage disposal of the evaporating panels is concerned a number of tests were performed under different weather conditions in April and May. Table 3 shows that the quantities of clarified sewage disposed range from 9.1 to 10.2 m^3/day.

Such results, which can be considered satisfying enough (even though the period of test "A" was characterized by high humidity values), were favoured by the high wind velocity. On average, hence, the average disposal amounted to 0.7 m^3/day for each panel.

The residue from the treatment of vegetation water (table 4) could be considered as a corrective fertilizer and namely a "fermented vegetable corrective fertilizer" after the necessary conversions obtained by mixing it with other organic substances and several phases of fermentation. The disposal capacity of the plant (table 3) varied 2.4 to 12 m^3/day. The results obtained reveal that when the weather is continuously particularly rainy, a sufficient wind velocity lacking, it is completely ineffective to maintain the plant in operation which is then to be closed to save energy.

When there is a strong wind blowing the sewage coming from the nozzles can overflow the panels and sometimes even the tank. It could be therefore suitable to lower the nozzles, as it occurred in the second plant, even doubling its number in order to have a better spreading of sewage on the evaporating surface.

Taking into account the maintenance of the plant, every month the evaporating panels have to be cleaned by means of a cold water jet cleaning device; this operation requires one worker/day. The conditions of the second plant were remarkably better than those of the first one. The capacity of the latter can be surely increased by cleaning its panels.

The energy consumption of the plant was limited by the absorption of the motor-driven pump meant for continuous feeding of the nozzles and the centrifugal separator in the first plant, since the other motor-driven pump and the air compressor worked at short intervals. Therefore, excluding redemption costs, energy consumption and running costs of the plant turn out to be rather limited.

CONCLUSIONS

The operating principle of the plant with evaporating panels taken into consideration accounts for a rather interesting solution for the disposal of agricultural sewage. Actually, it relies on a simple technology and requires a very limited energy consumption, since it uses renewable energy.

However, in order to overcome the drawbacks deriving from variable weather conditions, which prevent the panels from ensuring constant results during the year, and to allow to install also these plants in areas characterized by scarce windiness, systems of forced ventilation could be taken into consideration in the future. Moreover, aiming at further decreasing the energy consumption (which is, however, already very limited) the plant could be put into operation automatically only when favourable conditions occur; the operating field should be programmed as a function of the locality.

The maintenance of the plant is very simple provided that adjustment and cleaning of the different components are performed carefully in order to ensure an efficient performance of the plant as long as possible.

REFERENCES

1. Bonazzi G. and Martini P.P. 1987. Tecniche di trattamento dei liquami suinicoli per l'adeguamento allo scarico. Informatore Zootecnico 13: 30-34.
2. Fiestas Ros de Ursinos J.A. 1977. Depuracion de aguas residuales en las industrias de aceitunas y aceites de oliva.Grasa y Aceitas 28: 113-121.
3. Hobson P. N. and Robertson A.M. 1977. Waste treatments in agriculture. Applied Science Publishers, London.
4. Rossi N. 1990. Uso razionale dei liquami in agricoltura. Genio Rurale 6: 25-34.

Table 1. Content of nutritional elements in pig dung produced in Italy "Rossi N. (1990)".

Quantity of dung (10^6 kg/year)	19,800
Nitrogen (10^6 kg)	118.80
% of N	0.60
Phosphorus (10^6 kg)	25.70
% of P	0.13
Potassium (10^6 kg)	65.30
% of K	0.33

Table 2. Features of the separated solid portion in the treatment of pig breeding sewage.

Humidity		62.0%
Particle size measurement of dry matter	>2 mm	1.2%
	>1 mm,<2 mm	32.7%
	>0,5 mm,<1 mm	45.4%
	<0,5 mm	20.7%
pH (1:2,5 in H_2O)		8.2
Organic matter		11.0 C % dm
Total Nitrogen		1.4 N % dm
Ammonium Nitrogen		252 mg N/kg dm
Total Phosphorus		0.39 P_2O_5 %dm
Potassium		0.13 K_2O %dm

Table 3. Working conditions and results.

	Pig-breeding		Oil-mill	
	A	B	A	B
Temperature (°C)	14	17	28	28
Relative humidity (%)	90.0	65.0	27.5	69.0
Wind (m/s)	8.0	1.5	2.8	1.1
Disposal:				
m^3/h-group	0.061	0.054	0.250	0.050
m^3/h-panel	0.031	0.027	0.125	0.025

Table 4. Chemical and chemico-physical features of residue in the treatment of oil vegetation water.

pH in KCl..................	5.7
pH in H_2O..................	6.1
Organic Carbon.............	40% dm
Organic Matter.............	70% dm
Total Nitrogen	2.45% dm
C/N.........................	16.3
Total Phosphor.............	1.45 g/Kg
Humidity	54.4%
Residual humidity..........	7.75%

Fig. 1. Lay-out of the pig-sewage plant.