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

# MINIMIZING THE ENVIRONMENTAL POLLUTION OF PIG HUSBANDRY AND WASTE MANAGEMENT

Gy. Mészáros; Dr. B. Kuli; Dr. L. Fenyvesi; L. Mátyás

Hungarian Institute of Agricultural Engineering
Tessedik S. u. 4. H-2101 Gödöllő, Hungary

## ABSTRACT

Application of water-saving self-feeders can reduce water consumption of pigs by more than 50 %. So this feeding-watering system one of the most important way of the reduction of the slurry. Bioactive deep litter housing can eliminate slurry. Matured urine, faeces and litter can use for the purpose of soil conditioning and fertilizing. Water-saving slurry handling technology can halve manure dilution so it can double the nutrient content of the slurry. By using of straw bale biofilter for reducing emissions of pig houses makes fattening of pigs possible close to populated area. Developed rate control systems for slurry application make avoiding over-fertilization possible, can fulfill better the demand of nutrient of plants. By means of computer aided manure utilization system area distribution of soil characteristics can determinate. The system is suitable for planning the utilization of manure and slurry in environmental-friendly way.

Key words: slurry; minimizing; environmental; pollution; rate; controlled; planned; nutrient; utilization

## INTRODUCTION

In the latest decades manure application has pushed into the background in Hungary. Large scale animal-husbandry produces huge volume of slurry of low nutrient content and its utilization is unsolved. DM content of slurry from pig farms is generally no more than 3 %, Nitrogen, Phosphorus and Potassium content is 2-4 kg/m$^3$. One precondition of effective slurry utilization is the radical reduction of slurry production. Increasing of nutrient value and effective land application of slurry contribute considerably to decreasing of the environmental pollution.
Our R & D works spread over the main fields of minimizing the environmental pollution and waste management of pig husbandry.

## OBJECTS

### i. IMPACT OF WATER-SAVING FEEDERS ON THE REDUCTION OF WATER CONSUMPTION OF FATTENING PIGS

In the frame of an adaptation-developing work our object was to examine the effect of combined feeders on the reduction of water consumption. By the reduction of spilling water of drinkers dilution of faeces and urine can be considerably minimized.

### ii. ELIMINATION OF SLURRY PRODUCTION OF PIG HOUSES BY BIOACTIVE DEEP LITTER

Objects of this adaptation-testing work were to control the system Far-Eastern of origin in home circumstances and to elaborate the conditions of the application possibility in Hungary.

### iii. WATER-SAVING SLURRY HANDLING TECHNOLOGY FOR PIG FARMS

Object of the R & D project were to develop and to realize a water-saving technology for a pig farm with 450 sows. Development tended to the feeding-watering and the slurry handling system alike in order to reduce water usage, dilution rate of urine and faeces so the quantity of daily slurry production.

### iv. REDUCTION THE EMISSIONS OF PIG HOUSES BY STRAW BALE BIOFILTER

Object our research-development work is to test the efficiency of a biofilter made of straw bales for reduction the odour and gas emissions of pig houses.

### v. RATE CONTROL SYSTEMS FOR UNIFORM SLURRY APPLICATION

Two important requirements have to be fulfilled when applying slurry on arable land. One is to keep the ammonia emission on the possible lowest level, the other is to avoid the over-fertilization but ensuring the required nutrition elements for plants.

Purpose of our development of the slurry dose to be applied per hectare determined in advance with the knowledge of the nutrition supplying of the soil.

### vi. COMPUTER-AIDED SYSTEM FOR ENVIRONMENTAL-FRIENDLY UTILIZATION OF MANURE

In the framework of a joint R & D which was supported by the National Committee for Technological Development (*OMFB*) we have set the aim to elaborate a method that is suitable for determination the distribution of the nutritive supplying on soil surface. Another aim was to improve technologies and machines for field oriented distribution of nutritive materials.

## RESULTS

i. Combined self-feeders adjusted with nipple drinkers were applied and tested with 2x15 head of fattenings. Pigs were fattened from 45 kg to 100 kg live weight, between 125-205 days of age. Bowl type of drinkers were used by 2x8 head of pigs in two of control pens. Water consumption was measured by four water-meters.

Water consumption of the experimental stock varied between 1.8-3.2 litre per pig per day while this value was 5.1-9.1 litre in the case of the control stock. Water consumption of the experimental stock was 34.9 % in percentage of the control one. Water saving was 65.1 %. Results of the test are shown on Fig. 1.

ii. 2x15 head of pigs were fattened in two experimental pens, in two fattening cycles during 150 days. Height of saw dust litter was 80 cm (Fig. 2.). Two kind of bioactive agents were applied according to the directions. There was no exchange of litter during the fattening time.

Average daily gain of the 2nd stock was 646 grams with a feed conversion rate of 3.67 kg/kg. Temperature of litter in the centre of the litter was 45-50 °C (Fig. 3). Specific load of faeces and urine produced during two periods was 1,060 kg/m$^3$ litter. Against it the surface of the litter was semi-dry. Health of pigs was good. Pathogens e.g. E. Coli and Salmonella were not reported by laboratory analyses.

iii. Realized technology involves the following main elements:
- central filtration of drinking water
- equalizer water bins for decreasing pressure in water mains
- using of combined self-feeders
- measuring the quantity and screening of slurry
- treating of one part of separated liquid phase of slurry
- recycling of this treated liquid phase to the gutters of houses

Flow scheme of developed slurry handling system can be seen on Fig. 4.

At the time of elevation of the system pig farm was running 245 head of shows. Between 1st of January and 20th of April fodder consumption was 130.4 tons, while the slurry production was 614 m$^3$ with a DM content of 3.6 %. Dilution rate of faeces and urine against slurry was 2:1 in comparison with the state before reconstruction when this rate was 4:1. Separated solids from slurry was 72 tons. Treated and recycled liquid phase to one gutter was 8 m$^3$. Quantity of additives to the recycled liquid was its 0.2 vol. %. Reduction of slurry produced was more than 50 % in comparison with the original state.

iv. 16 head of pigs were fattened in the test house. Required air flow was 2,184 m$^3$/h. Inside surface of the straw bale filter (see on Fig. 5.) was 34.2 m$^2$. Specific load of air per m$^2$ filter surface was 66 m$^3$/h.

For filtering out the dust from the air of the house filter textile was applicated in front of the fan, inside the house. Filter resistance of the bales was only 10 Pa (1 mm w.c.). After 6 weeks of running wad-like colonies of fungus could be observed on the inner surface of the bales. According to odour tests, carried by sense organ, unpleasant odour could not felt against the characteristic "pig smell" inside the house. Olfactometric measurement will be done in this year.

v. In the interest of reaching the aim an RDS made volume control system based on an electromagnetic flow meter was adapted to a Hungarian made slurry tanker equipped with injectors.

During the field trials of the RDS Slurrymaster Rate Control System 885 $m^3$ of pig slurry was injected on 3x4 hectare fields. Adjusted application rate were 40-80-120 $m^3$/ha. Deviation to the adjusted rate were +1.7 %, -5.6 % and -4 % respectively. The required application rate can be adjusted within 0-200 $m^3$/ha at a step of 0.5 $m^3$/ha. The system raised the price of the tank approx. by 50 % "Mészáros at al. (1992)".

Beside this a control system was developed based on a Hungarian made electromagnetic flow meter.

As a further step of the development the analog volume control unit was replaced by a microprocessor rate controller and a wheel sensor was connected to it. On the control unit we can adjust the required rate, the allowed deviation, the circumference of the wheel, and the period of the valve operation. During injection the working speed and the actual value of the slurry rate can be displayed. The scheme of the SLURRYDOSE SD-03 Rate Control System can be seen on Fig. 6.

The price of the analog control system as well as the SLURRYDOSE Control System related to the above mentioned imported system is about 35-40 %. At the same time we have to mention that the disadvantage of the systems is that the flow meter operates on 220 voltages and the consumed power means a considerable load for the tractor battery. Uniformity of slurry application can be seen on Fig. 7.

vi. Owing to the required promptness and spatial tasks the remote sensoring-monitoring and measuring method was chosen. We have shown on model soil that the amount of different kind of humus can be determined by optical characteristics of the soil surface "Stefanovits et al. (1989); Fenyvesi and Papp (1991)".

According to laboratory experiments with soil patterns from Bábolna, we have shown that the humus content was unambiguously, while the amount of iron and lime, beside certain conditions, was determinable by the help of optical characteristics "Mészáros et al. (1993)". Better approach was reached in the visible range. However, measuring in 800-1,200 nm range is suggested because disturbing effect of atmosphere is less considerable.

Relations among colour characteristics, humus and lime content are shown on Fig. 8. On the basis of the connection set up distribution of organic carbon and lime can be drawn.

On the examined field the least quantity of both the potassium and the phosphorus is more than the values are given in handbooks. According to our supposition crop yield is determined mainly by the nitrogen content. For determining the distribution of the yield we have taken normal colour photos.

Remarkable that the quantity of crop is determined not only by nitrogen to be in deficiency, but the organic carbon too.

$$N = 0.039 - 0.0013\,H + 7.361 \times 10^{-6} G$$
$$r = 0.966$$

where N: Nitrogen content [g/kg]
H: Humus content [g/kg]
G: Mass of corn-cob [g/kg]

By the help of the gained connection, distribution of the nitrogen can be drawn. In the soil of the other test field amount of all macro elements was more than the given maximum value. In this case the crop yield is determined by the humus content. Amount of humus can be given by the help of the infrared photo as it was described.

Distribution of yield is the same as the distribution of the organic carbon. In this manner on the basis of the green mass to be harvested decreasing the macro elements of the plot can be calculated.

## CONCLUSIONS

By means of application of devices, equipment, technologies and measuring-evaluation methods, developed during years of R & D work in our institute, advantages are as follows:

- minimizing of water consumption and odour emissions of pig farms;
- considerable reduction or elimination of slurry production;
- increasing nutrient content of slurry;
- distribution of slurry in the required rate;
- application and utilization of slurry according to all the requirements and demand of soil and plant by advanced methods and systems.

## REFERENCES

Dobbelaere, A; Mészáros, Gy; Mátyás, L. 1991. Technical possibilities for a uniform spreading of slurry and a reduction of the environmental impact. FAO/REUR Techn. Series 17: 40-46.

Fenyvesi, L; Papp, Z. 1991. Remote sensing for nutrient and field mapping. Int. Symp. on Locating System for Agric. Mech.; Proceedings: 94-97.

Mészáros, Gy; Mátyás, L. 1991. Guideline proposals for application of different keeping methods and manure-slurry handling equipment. FAO/REUR Techn. Series 17: 93-105.

Mészáros, Gy; Mátyás, L; Kuli, B. 1992. Developing tank vehicles equipped with electronic volume control system for dosed injection of slurry.
Hung. Agric. Eng.; Gödöllő; 5/1992: 20-21.

Mészáros, Gy; Mátyás, L. 1992. Moderating the environmental damage caused by slurry.
Hung. Agric. Eng.; Gödöllő; 5/1992: 19.

Mészáros, Gy; Mátyás, L; Kuli, B. 1992. Possibilities for minimizing the environmental impact of the animal production.
AgEng '92. Int. Conf. on Agric. Eng. Uppsala; Proceedings: 274-275.

Mészáros, Gy; Fenyvesi, L; Mátyás, L; Kuli, B; Horinka, P. 1993. Measuring method for evaluation of the nutrient supply of the soil.
Int. Conf. on New Strategies for Sustainable Rural Development. Gödöllő.

Papp, Z; Fenyvesi, L. 1992. estimation of some features of soil content by the optical characteristics of the surface.
1st Alps-Adriatic Workshop on Satellite Data Evaluation and GIS Technologies, Keszthely; Proceedings: 26-30.

Stefanovits, P; Micheli, E; Fenyvesi, L. 1989. Infrared reflectance of artificially prepared organs-mineral complexes.
Int. Agrophysics: 99-105.

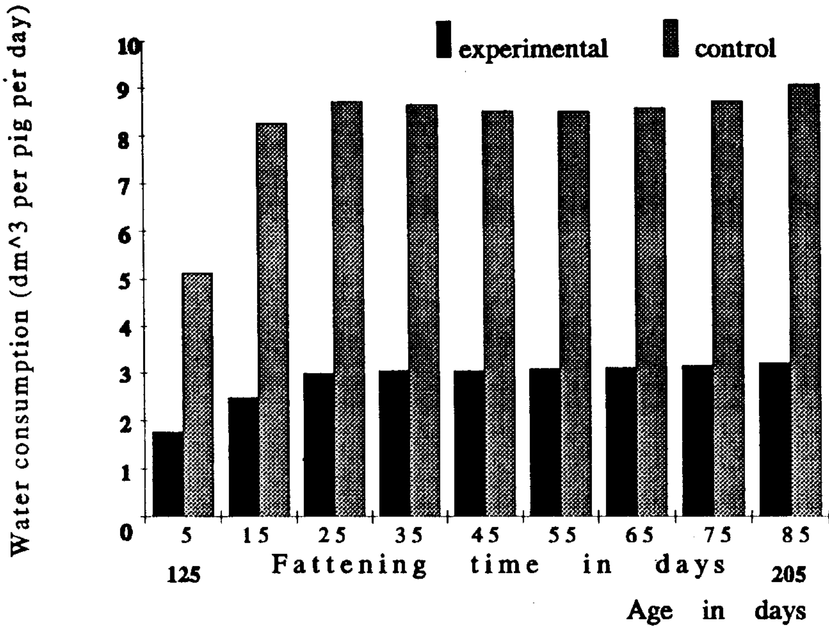
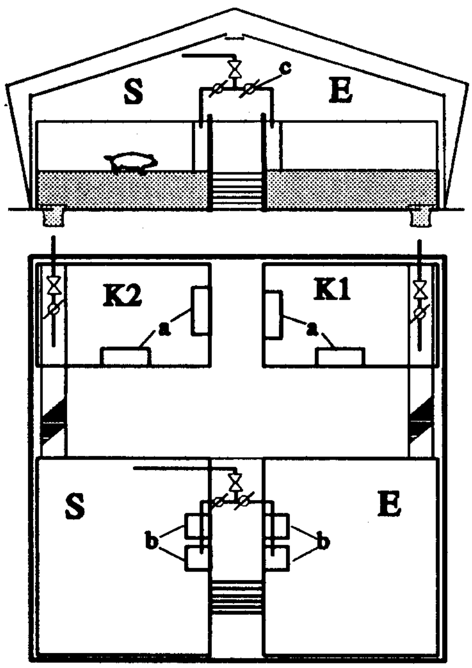



Fig. 1
Daily water consumption




a./ self-feeders,

b./ combined self-feeders,

c./ water-meters,

S: SEF-C treating,

E: ENVISTIM treating,

K1 & K2: control pens

Fig. 2
Layout of the deep litter experimental house

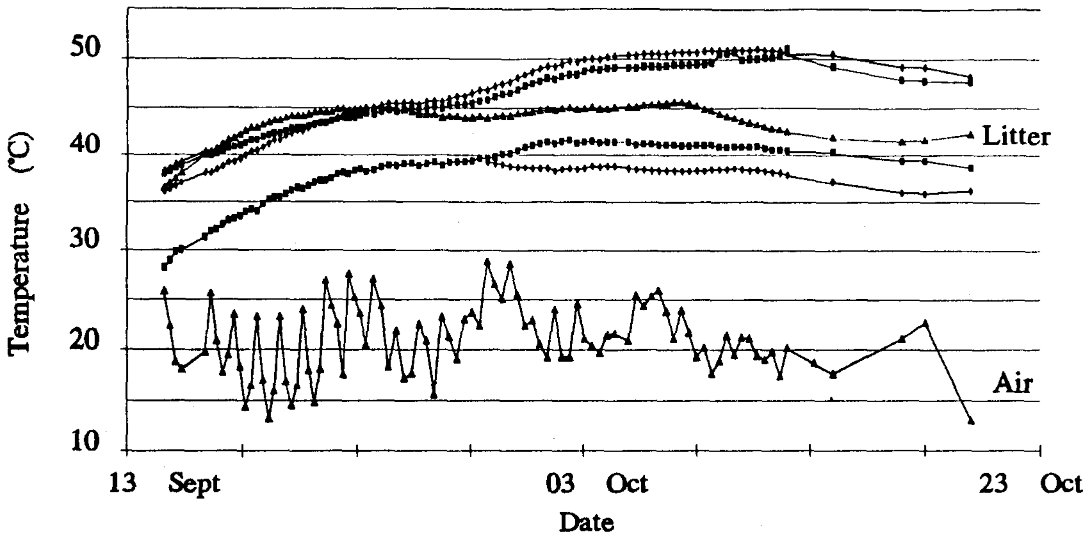
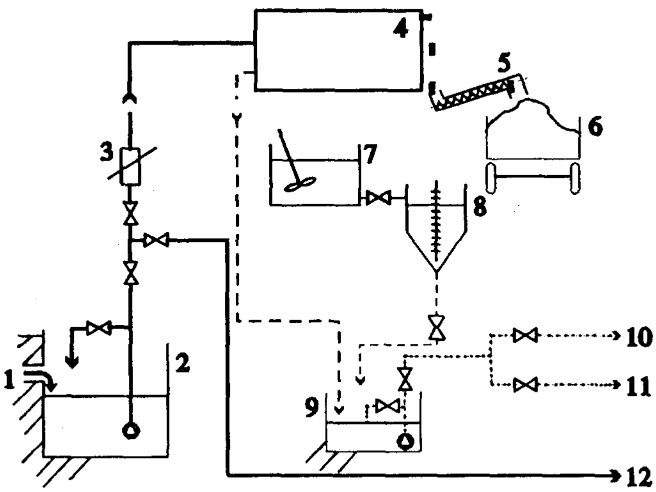



**Fig. 3**
**Temperature of deep litter and the air in the house**




1./ collecting gutter of the pig farm,
2./ collecting pit,
3./ flow meter and summarizer,
4./ drum screen,
5./ auger for separated solid phase,
6./ trailer,
7./ bin for treating material,
8./ metering device,
9./ temporary storage for treated liquid phase,
10./ recycling of treated liquid phase to the gutters of the house,
11. 12./ separated liquid phase towards storage basins.

Line codes:

——— slurry, ------ separated liquid phase, ▪ ▪ separated solids,

----- treating material, .............. separated and treated liquid phase

**Fig. 4**
**Flow scheme of developed slurry handling system.**

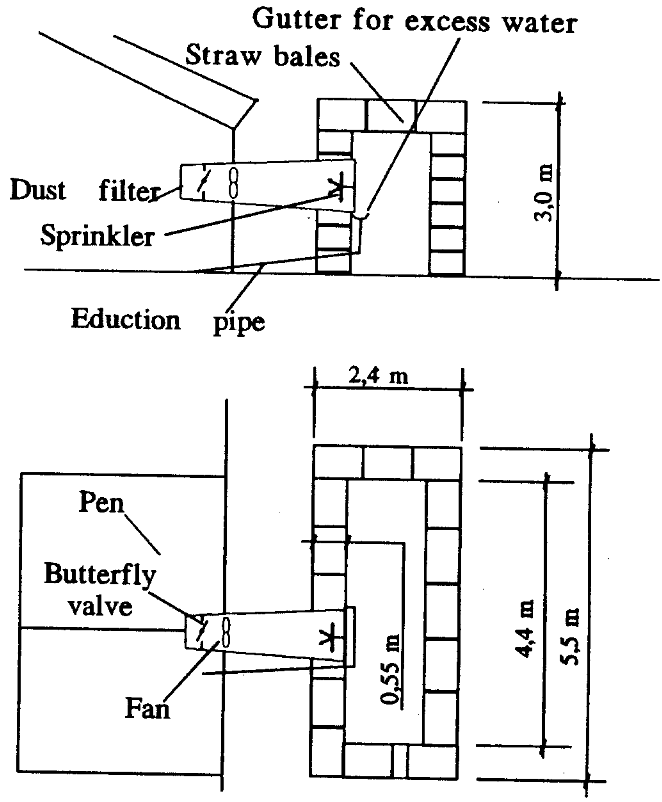
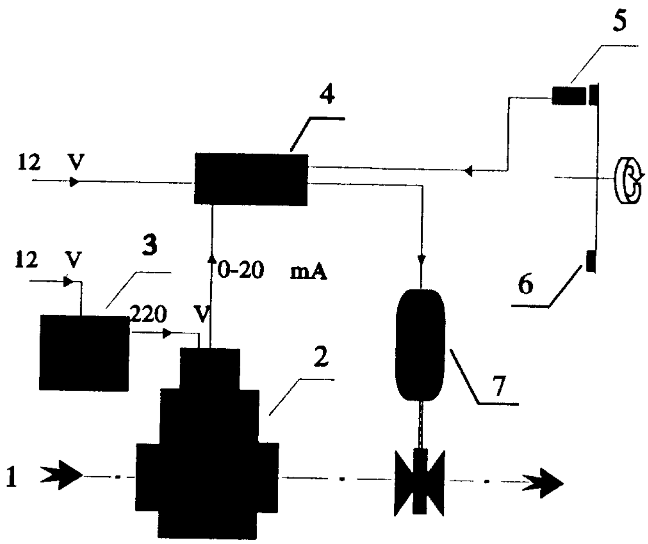



**Fig. 5**

**Layout of the straw bale biofilter**




1./ flow
2./ electromagnetic flowmeter /Gamma Analcont/
3./ DC/AC converter
4./ volume controller /SD-03/
5./ wheel sensor
6./ wheel magnet
7./ motor valve

**Fig. 6**

**Scheme of the slurrydose SD-03 rate control system**

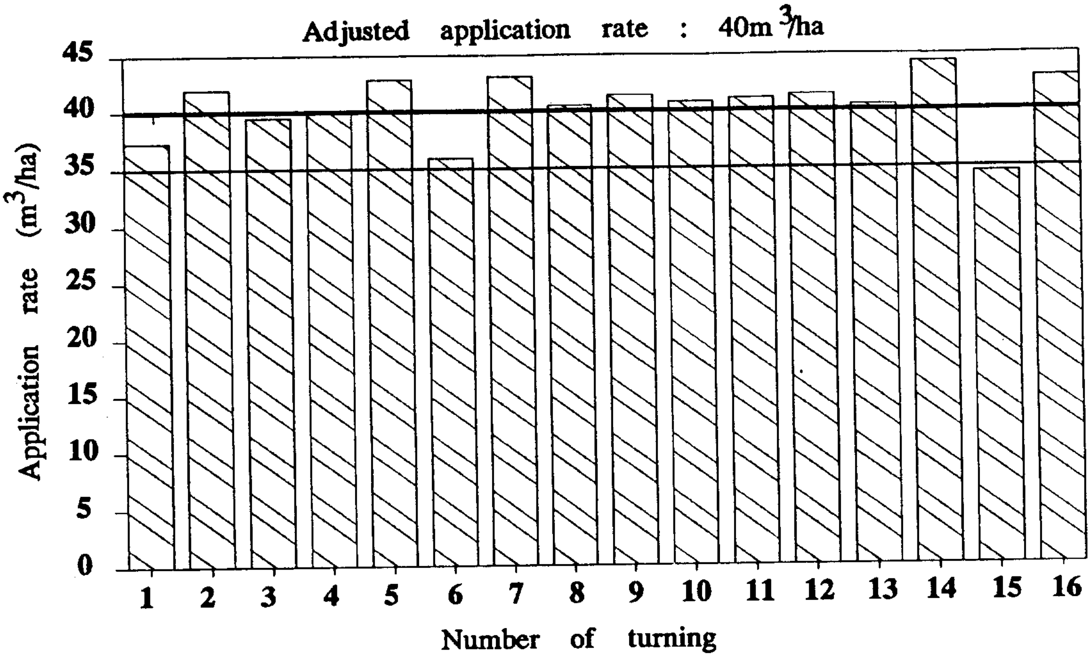



**Fig. 7**
**Uniformity of slurry application**

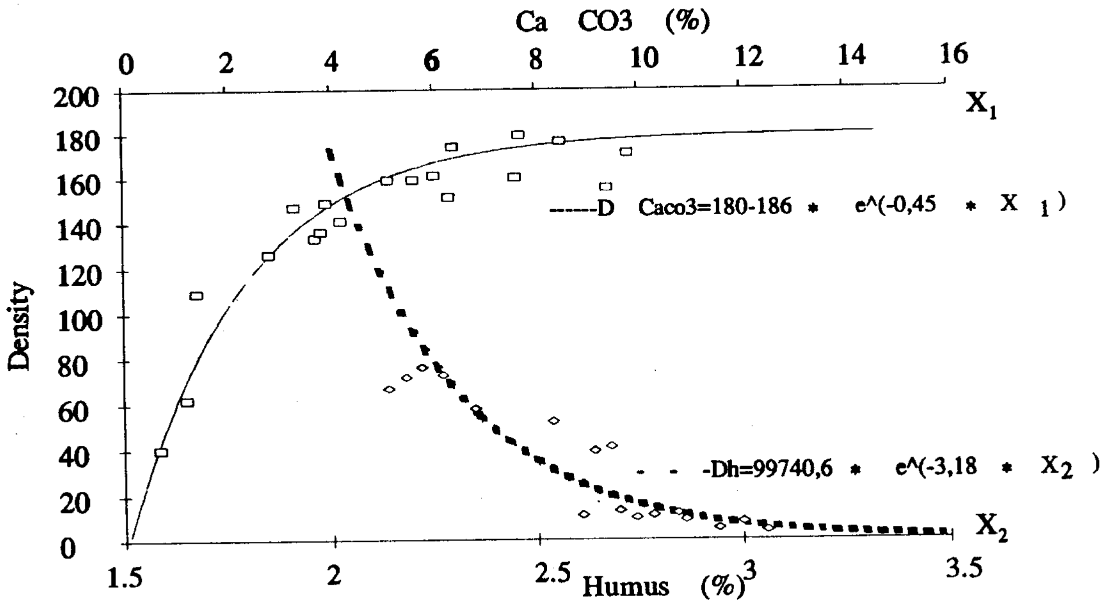



**Fig. 8**
**Relations among colour characteristics, humus and lime content**