# AUTOMATIC MANAGEMENT PROCESS IN HYDRODYNAMIC WASTEWATER IRRIGATION IN DILUTION

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***Abstract.*** Hydrodynamics has had several decades a predominantly experimental character mainly due to the difficulties of obtaining valid general solutions of the equations of motion (Navier-Stokes, Reynolds etc.). It constitutes the main part of fluid mechanics because the other static and cinematic chapters-though particularly important-they, particularly the last-few practical applications. The last decades have established the development of numerical methods to integrate the equations of motion for the concrete cases studied by the researcher, due to the rapid development of computing resources. In this paper has been addressed the issue of control of the hydrodynamic processes specific automatic systems of wastewater treatment plants with the application using these partially purified water. It is presented a multi-criteria approach, comparative management techniques of industrial automatic irrigation of agricultural land use in wastewater dilution, with significant positive economic results of all irrigation facilities.
***Keywords*:** multi-criteria approach, control system, irrigation, wastewater, hydrodynamic processes, adaptive control.

## 1.INTRODUCTION

The technological installation mentioned before is intended for the distribution of wastewater on fields through the irrigation system. The water comes from a pig breeding farm near Constantza.

The research made by experts had shown that wastewater in dilution with clear water can be used directly to irrigate the fields. The irrigation system using wastewater in dilution was conceived and technically implemented so that:

- It ensures the achievement of technical-economical parameters registered on the hydraulic installation;
- It ensures that the hydraulic installation of transport and distribution of wastewater will run for a long time;
- it also ensures the achievement of high efficiency;
- It enhances the fruitfulness level of the irrigated soils and as a result, the yield.

The main purpose of this project was to identify the ways in which can be ensured high reliableness and long-lasting efficiency.

The implementation of a command and automatic control system of the hydrodynamic processes that appear in the transport and distribution of wastewater installation has as a main goal the efficiency of exploitation by:

-ensuring hydraulic conditions that are necessary for the running;

-perfectioning the functioning power of the hydraulic installation;

-achieving and maintaining the water quality parameters through controlled dilution of wastewater.

Wastewater properties after decantation in the physical stage are specified in Table no.1. They will change after the dilution with conventionally clear water, [1].

Table 1. Wastewater properties

| No. | Parameters | U.M. | Range of variation |
|---|---|---|---|
| 1. | pH | - | 6,8…8,0 |
| 2. | Rude suspension | mg/l | 1900…2100 |
| 3. | Fix residue | mg/l | 1500…3250 |
| 4. | Total nitrate | mg/l | 270…620 |
| 5. | Total phosphorus | mg/l | 25…95 |
| 6. | Total potassium | mg/l | 180…260 |
| 7. | Ammonium | mg/l | 172…185 |
| 8. | Nitrate | mg/l | 0,55…0,575 |
| 9. | Carbolic | mg/l | 0,02…0,03 |

## 2.THE EXPERIMENT

### 2.1. The modellation of the irrigation installation and the selection of the regulator

The modellation of the irrigation installation and the selection of the regulator. The modellation of the hydraulic installation, shown in figure 1 and modellation equivalence scheme in figure 2, intended for the irrigation process of fields aims to establish a characteristic equation useful for setting up an automatic control management system.

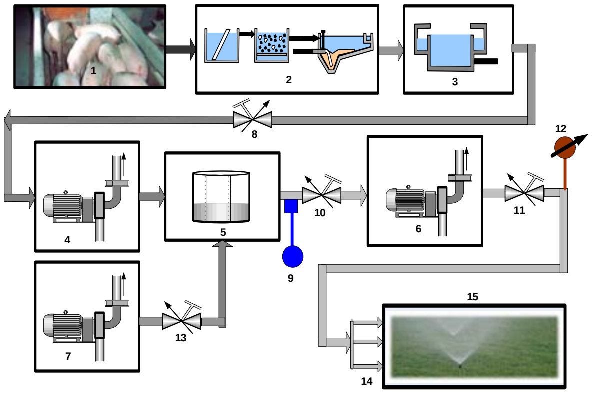


Fig.1. Hydraulic installation scheme

Hydraulic training through dilution of waste water, transportation and distribution is made up of:
1. Animal farm (1);
2. Physical purification Step TFE(2)-raw wastewater containing a BBQ, fat separator, and finally a settler; It is intended for large bodies and apprehension of the suspensions of mineral or organic nature which may be lodged on the ducting;
2. Pumping station (4) in sewage sludge trap SPUZ-dressed for a flow rate of 100 l/s or 360 $m^3$/hr at continuous operation 24 hours/day;
3. The waste water pipe AS-decanted from the pumping station to the storage buffer basin wastewater; the length of this pipe with a diameter of 300 mm is 8000 m; it is provided with sewerage manholes and parts cleaning;
4. BT-buffer Basin of water (3) has a volume of 750,000 $m^3$ corresponding to a storage period of six months; of the effluent will take samples for bacteriological and virological examination;
5. mixing tank of wastewater and clean conventional RAM(5); the effluent is placed at a higher pressure with (3...5) $mH_2O$ to achieve injection and mixing by forming a powerful swirl; for controlling the degree of dilution is a transducer which allows concentration, flow rate adjustment, through its amendment;
6. pumping station and pressure that is intended for delivering SPP water diluted(6) in transmission and distribution network on the ground; She works 10 hours a day throughout the duration of irrigation, at a pressure of 66.25 $mH_2O$;
7. transportation network RTr-is built from pipes buried; There is a possibility that through these pipes to pump and clean water for money laundering purposes; buried pipes have a diameter of 125.225 mm in the case of PVC and running (200...350)mm from asbestos-cement pipes; the antennae are located (the distribution pipes) that are replacing hydrants-water-holes for connecting mobile equipment for watering; transmission network are mounted overhead installations dezaerisire, valves and vent line, anchorage, massive water outlets etc.; the water is directed to the antennas, placed at variable distances, opening of valves; in the lowest points of the equipment shall be provided for draining valves;
8. distribution network of irrigation plant RDis-which is linked directly to the antenna; battery installation is fitted, one side of the antenna, and another for coverage of large areas of land; ensure pipes dripping water through the drain holes located at (0.7...0.8)m; watering system is sized at a flow rate of 15 l/s for 20 days, with a continuous running 20 hours a day in summer; water flow watering is dependent upon temperature, soil permeability, slope, soil type, crop, etc.;
9. wash with water pipes clean conventional-are designed to steer the water hydraulic transmission and distribution in order to ensure washing pumps and pipelines after a period of working with waste water (15...20) days; the speed of movement of water clean is (2...3) times higher than that of work so as to ensure the involvement of and removal of deposits formed during the operation of the waste water.

Modeling of hydraulic installation, shown in figure 1, to process farmland irrigation aims at determining the characteristic equations helpful in conceiving a system of automatic control and management of it.

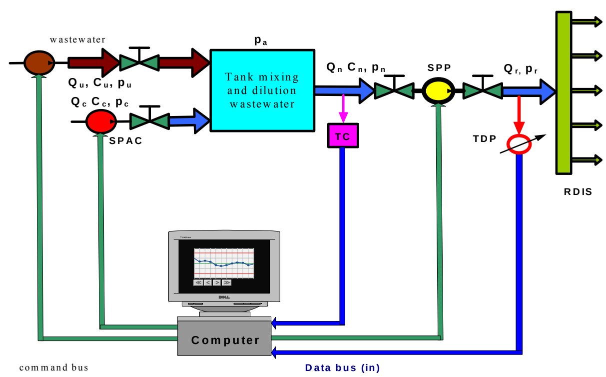


Fig.2. Equivalent modeling schema

Equivalent Schema modeling facility comprises: TC-concentration transducer; TDP-flow and pressure transducers; SPAC-conventional water pumping station clean; SPP-pumping station and pressure; RDIS-water distribution network on the golf course. The settings of the installation shall be made in the following sizes:
1. Debit adjustment for the concentration of $c_c, Q_c$ range of values;
2. Adjustment system with variable speed giving rise to variable flow pump for flow and pressure imposed by the distribution system in furrow.

In the final stage of the installation it is required a flow control $Q_r$ and pressure $p_r$, both necessary for the irrigation of the fields. On this installation, we have the equations:

$$Q_u + Q_c = Q_n \quad \text{- hydraulic balance,} \qquad (1)$$

where: $Q_r = Q_n$ - massic balance. (2)

$$Q_u \cdot c_u + Q_c \cdot c_u = Q_n \cdot c_n \qquad (3)$$

where: $c_n$ - the concentration of the mix obtained in the mixing tank must be maintained within the limits mentioned in table 1.

For the regulation and maintainance of the concentration, the conventionally clear water flow control shall be modified, [3].

The adjustments of the installation are made through, [2]:

1.Flow control adjustments ($Q_c$) to maintain the concentration ($c_c$)within the parameters;

2. Adjustments to the variable speed system that carries the variable flow control pump to ensure the flow control and pressure required by the distribution system.

The principles of mathematical modeling, [3]:

1. In a physical system analysis it is required the formation of a conditioned system: the number of the equation and the number of X's are equal.

2. The value of the physical constants in the system must be correct and justified physically.The pressure in the recipient is constantly maintained at the level of the clear water circuit. In the hydraulic installation we have:

$p_c \langle p_u -$ wastewater is injected in the mixing recipients;

$p_a \langle p_c -$ the pressure from the mixing tank is smaller than the pressureof the injected clear water;

$p_a \langle p_u -$ this pressure imbalance will allow the injection of the wastewater.

Due to the different pressure values, the following can be said:

$Q_u = K_1 \sqrt{p_u - p_a}$ -for the wastewater flow control; (4)

$Q_c = K_2 \sqrt{p_c - p_a}$ - for conventionally clear water flow control; (5)

$Q_n = K_3 \sqrt{p_a - p_n}$ - for mixed water flow control, (6)

where: $K_1, K_2, K_3$ are flow control constants of the induction apertures.

The equation of flow control variation is influenced by the variation of the pressure in time. If the division of flow controls in the mixing recipient is taken in consideration (figure 3), the following equation can be written, [3]:

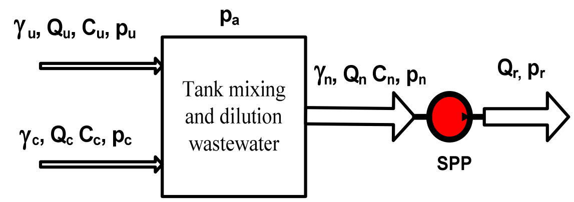


Fig.3. Calculation scheme

$$\frac{A}{\gamma_a} \cdot \frac{dp_a}{dt} = Q_u + Q_c - Q_n \qquad (7)$$

where: $\gamma_a$ - the specific weight of the wastewater and clear water mix expressed in the following equation:

$$\gamma_n = \gamma_u \cdot c + \gamma_c \cdot (1 - c) = \gamma_c \cdot \left(1 + \frac{\gamma_u - \gamma_c}{\gamma_c} \cdot c\right) = = \gamma_c \cdot (1 + a \cdot c) \qquad (8)$$

- $Q_a, Q_c, Q_u$ – flow control (time functions);

- $A$ - constant – the transversal section of the mixing recipient.

Therefore, the following can be said:

$$\frac{A}{\gamma_a} \cdot \frac{dp_a}{dt} = Q_u + Q_c - Q_n = f(t) \qquad (9)$$

function continnue in time.

There can be a slow variation for pressure $p_r = p_r(t)$ and also $Q_n = Q_n(t)$. The pressure is:

$$p_r = p_a + \Delta p - K \cdot Q_n^2, \qquad (10)$$

where: Δp - contribution of pressure pump.

Upsetting flow control is:

$$Q_r = K_4 \sqrt{p_r - p_{at}} \qquad (11)$$

If in equation (1) the flow controls are replaced, the following is obtained:

$$\frac{A}{\gamma_a} \cdot \frac{dp_a}{dt} = K_1\sqrt{p_u - p_a} + K_2\sqrt{p_c - p_a} - K_3\sqrt{p_a - p_n} \qquad (12)$$

or if $Q_r$ is replaced :

$$\frac{A}{\gamma_a} \cdot \frac{dp_a}{dt} = K_1\sqrt{p_u - p_a} + K_2\sqrt{p_c - p_a} - K_4\sqrt{p_r - p_{at}}, \qquad (13)$$

in which the law of variation of the lifting pressure in time can be introduced. For example, it is considered the necessity of decreasing the lifting pressure and implicitly the flow control in time (at daytime the flow control is bigger and in the evening it can be continously decreased until shut-down). This will lead to a continous reduction of energy, therefore to an efficient exploatation.

In equation (1) the specific weight of the mix can be inserted and the result is a differential equation that connects the three elements: the flow control, the concentration and the pressure.

It obtains:

$$\frac{1}{Q_u + Q_c - Q_n} \cdot \frac{dp_a}{dt} = \gamma_c \cdot (1 + a \cdot c) \qquad (14)$$

Through liniarization the flow control and pressure equations, we obtain an equivalence functional scheme with multivariabil at input and output, who is bring in figure 4 (includes the regulation scheme), [1] [3].

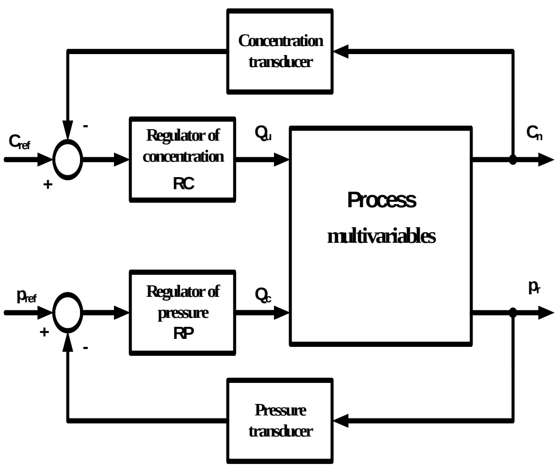


Fig.4. Functional scheme for regulation system

## 3. EXPERIMENTAL RESEARCH

### 3.1. The case study

Experimental research aimed to determine the functional parameters of hydraulic installation intended to irrigate farmland with wastewater decanted beforehand. Research conducted by biologists and specialists in the field of agriculture have shown that wastewater from evaluate complexes, can be used for irrigation since the substances contained in the liquid fertilizers have qualities.

To be able to be applied to agricultural lands sewage decanted must meet the following conditions:

-do not constitute a source of pathogens that can cause illness in humans and animals;

-do not contain any heavy metals or organic synthesis compounds (PAHS, PCBS, etc.) over the maximum permissible limits (Alcock and Associates, 1995, McGrath and colleagues, 1994);

-to comply strictly with the recommended technologies (applies only to facilities on land, in the recommended doses, at the right time and with the means, to a structure and rotation of crops suitable for an optimal period of time etc.).

Pretability level criteria for land administration decanted waste water are as follows:

1. Topography (neumiformitatea land);
2. The slope of the terrain affects the speed and quantity of spills on the place;
3. Soil texture influence seeping speed and ability of adsorption to soil;
4. The permeability of the soil directly influences on the distribution of soil water profile;
5. Drainage processes direct influence on soil physical, chemical and biological weapons that are held in the soil;
6. Surface runoff and erosion will be avoided on land soil irrigation will apply;
7. Floodplains are not intended for irrigation with wastewater decanted;
8. Water capacity useful depth 0-100 cm or until the limiting layer, c 1400 > $m^3$/ha;
9. Depth of groundwater directly influences the sludge.
10. Edafic volume has a special role in the application of the method of irrigation. ;
11. Soil pH influence greatly the degree of mobility of heavy metals;
12. The capacity of cationic Exchange strongly influences the soil on the mobility of heavy metals;
13. Laden with heavy metals;
14. Protection of water sources and of localities.

The industrial plant is intended to irrigate farmland with wastewater from Poarta Alba animal farm ISCIP Nazarcea. The volume of waste water is decanted 1,500,000 $m^3$/year.

Storage basin allows for forfeiture of a quantity of wastewater 730.000 $m^3$ over a period of six months. Pumping station with pressurised implementation throughput 23 l/s at a load of (23...55) $mH_2O$.

The pressure is necessary for $mH_2O$ 23.5 watering in the furrow, and the 55 $mH_2O$ if wetting sprinkler-spraying.

After the pumping, wastewater is needed to wash hydraulic plant and mobile equipment with conventional water watering clean. After each cycle of watering for (15...20) days/month shall wash for (3...5) hours depending on the length of the pipeline, with a water flow rate of (2...3) times higher (for the reantrenare). Conventional water scrubbing is done for reasons of hygiene, but also for attracting deposits from the inside of the pipe.

The watering hole has set (0.7...0.8) m to ensure the water supply on the furrows. The sprinkler has nozzles of 6 mm at 3 bar pressure.

In order to assess the amount of available water wetting with wastewater quantity variation was based on the number of animals in the complex. It has developed a program in Matlab to determine the theoretical curve that best fits the experimental data. The data has been approximated by an exponential curve and then through a polynomial of degree 2.

The results obtained from running the program are the following:

1. Wastewater Quantity depending on the herd of pigs

a. harmonization of data with an exponential curve

The coefficients of the polynomial have resulted logp1 0.0000 0.0000 1.8517 so the curve approximation is log10 (au) = 0.0000np2 + np + 1.8517 101.8517 = np or, where the quantity of the water supply-[thousand $m^3$], and np-the herd of pigs.

Determine the values for the amount of waste water, according to the theoretical curve (figure 5 and 6):

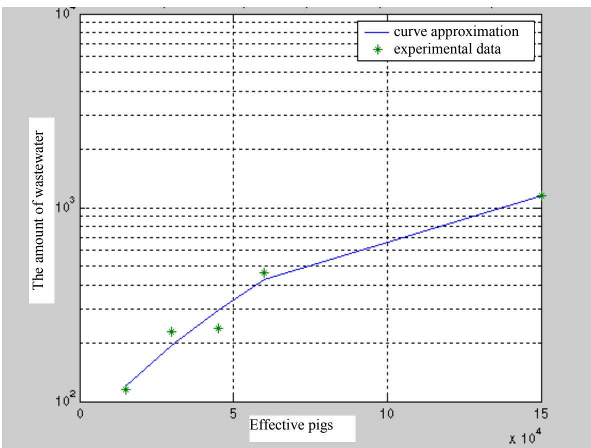


Fig.5. Approximate exponential curve, the amount of wastewater-effective pigs

All these curves shown above, resulting from the processing of experimental data, are particularly useful in determining the functional parameters of the plant watering, as well as an indication of availability of water for irrigation. The operation over a period of about two decades of hydraulic equipment for farm land with wetting wastewater decanted this procedure has proved its efficiency irrigation without reporting to the outstanding issues relating to the health of plants and animals.

The operation of these installations requires the use of a command and control system of the hydraulic system of automatic watering. Only in this way will be able to maintain the concentration of the diluted water wastewater pure conventional values imposed by technology.

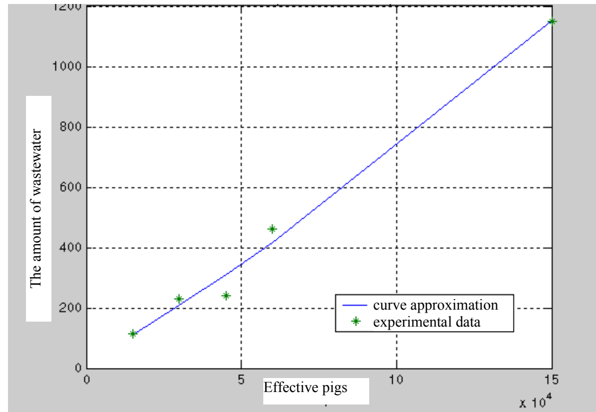


Fig.6. Curve approximation with a polynomial of degree 2, amount of wastewater-effective pigs

At the same time it enables effective control of the watering process con-diţiile obtaining important savings in electricity. Thus, there is the possibility of major savings to fund wages and in terms of costs-especially energy costs-which will lead to a high efficiency irrigation farmland.

As a whole, through consideration of the hydraulic installation of watering of the wastewater treatment plant is equipped with a natural step, will get big savings from operating funds because it can count on the process of autoepurare of soil irrigated with wastewater decanted. Is deleted, thus energy consumptions of biological purification stage and gives a rational use of wastewater discharged from the animal farm.

### 3.2. The numeric simulation of the multivariable system

To obtain more command measures necessary to achieve the action of automatic adjustment of the multivariable technological installation it is obligatory that the automatic regulator is multivariable, meaning that he must receive more error measures, reshaping them after fixed laws, and to ensure the achievement of more command measures.

The achievement of more error measures requires the evaluation of more reference measures and the comparison of these with the final measures transmitted to the comparison elements through several principal negative reactions.

The results are a multivariable adjustment system which has multiple transmition channels.

The result of the matrix method is the numeric simulation of the analysed system diagram using the simulation method Matlab-Simulink, present in figure 7,[3].

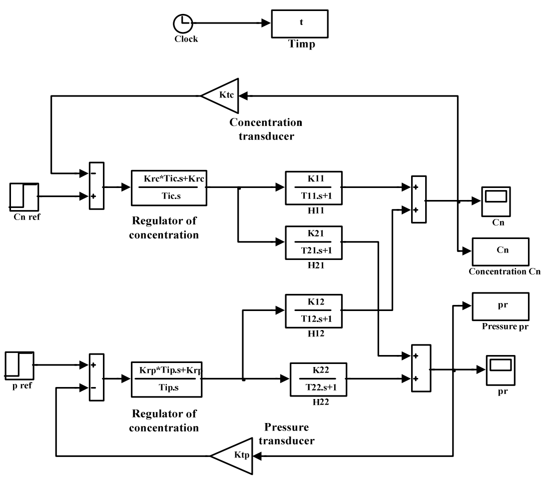


Fig.7. Numeric simulation scheme using Simulink

The simulation data can be found in the programme date.m.

## 4. RESULTS AND INTERPRETATIONS

The results of the numeric simulation are represented in figure 8 and 9. In figure 8 is a variation of the pressure in irrigation pipes when the adjustment is carried out via a pressure regulator type PI, and in figure no. 9 shall represent the change in the concentration of the mixing tank clean the water supply. In this case the maintenance of concentration limits set in is done via a concentration regulator which evolves after a law PI.

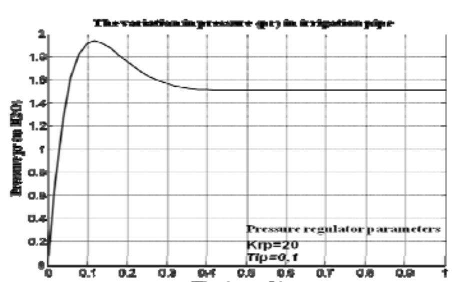


Fig.8 Variation of pressure $p_r$ in irrigation tube

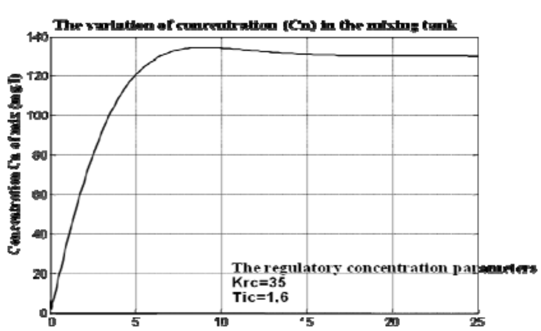


Fig.9. Variation of concentration Cn in mixed tank

## 5. CONCLUSIONS

The analysis of the data obtained it appears that pressure from irrigation pipes are significantly higher when using wastewater than the situation where using clean water. Pressure differences are between 11.2 and 13.1 mca mca, having the effect of altering the operation of pumping equipment and energy savings.

At the same time in the previous analysis graphs can be drawn the following conclusions:

- By adjusting the accord parameters of the automatic regulators, a stabile reserve can be ensured;
- The performances of the multivariable system depend on the measures of the accord parameters. By choosing correctly these measures it is possible to maintain the performances within the required limits;
- The simulation diagram has a general character and it can be used for every adjustment structure belonging to this category, mentioning that the automatic process has to be appropriately modeled;
- The implementation of the adjustment structure with numeric process regulators allows the distribution of the management and supervising functions for other measures in the process.

Rational distribution of decanted waste water from pig complexes leads to:

a) Reducing water consumption for irrigation source taken from about 750 $m^3$/ha;

b) Reducing the consumption of fertilizers per hectare with: 148 kgN, 109 kg $P_2O_5$ and 37 kg $K_{20}$;

c) Increased production per hectare farm with 5%;

d) To obtain organic products.

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