STUDIES AND RESEARCH ON WATER LOSSES FROM IRRIGATION SYSTEMS

Ștefan-Andrei STICEA[1], Alexandru-Lucian LUCA[2], Nicolae MARCOIE[1], Mihail LUCA[1]

e-mail: mluca2015@yahoo.com

Abstract

The advanced degree of wear of the irrigation system infrastructure determines the occurrence and maintenance of water losses. The research was conducted in irrigation systems located in the eastern part of Romania and which have different periods of operation, but all performed before 1990. The research highlighted the complexity of the process of degradation of structural elements and the development of water loss. The structural degradation of the canals and pipes under the action of natural and anthropogenic factors determined the appearance of water losses and, implicitly, the decrease of the hydraulic efficiency. The research highlighted a degree of degradation of the supply and distribution channels of about 40-60%. An important influence in the degradation action was the absence of maintenance and repair works. Significant water losses are recorded in the pipelines. Their value reaches 18 - 27% of the transported flow, being determined by the wear of the material and the aging of the components of the hydraulic installations. Water losses are of the visible, hidden and background type. The use of European funds to rehabilitate irrigation systems requires reducing water losses.

Key words: basins, canals, hydraulic efficiency, monitoring, water leaks

At the level of 1989, Romania had a series of irrigation systems with a technical level corresponding to the existing technologies and execution materials at national and international level. Irrigation systems have been designed to complete the water supply for the development of agricultural and horticultural crops in the climatic conditions of Romania (Blidaru V. *et al*, 1981, Cazacu E. *et al*, 1982).

After 1990, most of the existing irrigation systems in Romania were abolished for various reasons; the change of ownership of the land and government decisions was the main causes. At present, a small number of irrigation systems built before 1989 are in operation. The irrigation systems in operation have degradation processes at the construction structure and at the installations that serve the operation process. (Luca M. *et al*, 2016).

Irrigation systems built before 1990 were composed of water source, pumping stations that raised water at various levels, transport channels, pressure stations or bivalent watering, conduits, hydrotechnical bypass nodes protection and control facilities and so on (Blidaru V. *et al*, 1981, Cismaru C., 2004).

Water losses from the network of canals and pipes are permanently present in the process of operation of irrigation systems. Water losses influence the hydraulic efficiency of the components of the irrigation system, but also the operating costs in a negative way. Water losses have been present since the establishment of the system, and their value varies over time.

The infrastructure of the irrigation systems (water intake, basic pumping and re-pumping stations, discharge pipes and supply and distribution channels, etc.) is managed by the Romanian state. The irrigation plots were taken over by the private operating system. The researches show that the irrigation systems in operation show degradation processes of the constructive structure and the hydraulic installations for water transport (Luca M., 2012, Luca M., 2015, Luca M., 2020).

The network of pipelines and canals was executed between 1975 and 1978 and has exceeded its operating time. This situation currently causes a large number of damages during the operation process. The use of European funds in the rehabilitation of irrigation systems requires the reduction of water losses (Cismaru C., 2004, Luca M. *et al*, 2017).

The objective of the paper is to analyze the types of water loss present in the infrastructure of irrigation systems currently in operation and how to monitor them.

[1] „Gheorghe Asachi” Technical University, Iasi
[2] Polias-Instal Company, Iasi

MATERIAL AND METHOD

The research area belongs to the arid climate zone of Romania (*figure 1*). The material used in the research consists of a series of irrigation plots located in the eastern part of Romania, respectively in Iaşi and Vaslui counties (figure 2).

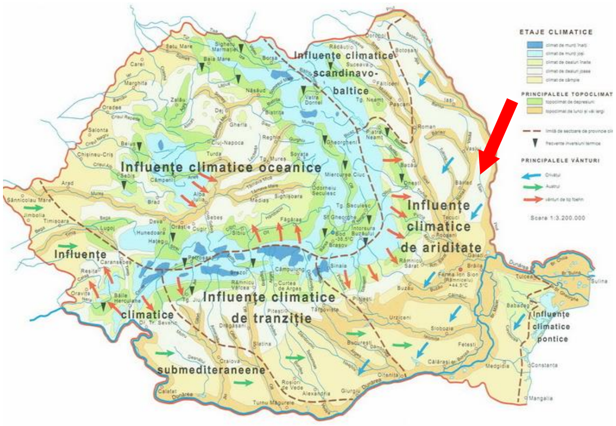


Figure 1 **Location of the researched area in the climatic zones on the Romanian territory**

The irrigation systems analyzed are fed from the Prut River. Irrigation plots are located in the meadow and terrace areas of the Prut River (*figure 2)*. The basic pumping stations (SPB) take water from the Prut River and discharge it through pipes into the canals in the meadow area. The terrace area is fed through the discharge pipes of SPB and SRP (pumping stations), which are connected to the supply and distribution channels. The pumping and pressurization stations (SPP) of the irrigation plots are fed from the canals (Luca M., 2015, Luca M., 2016, Luca M., 2020).

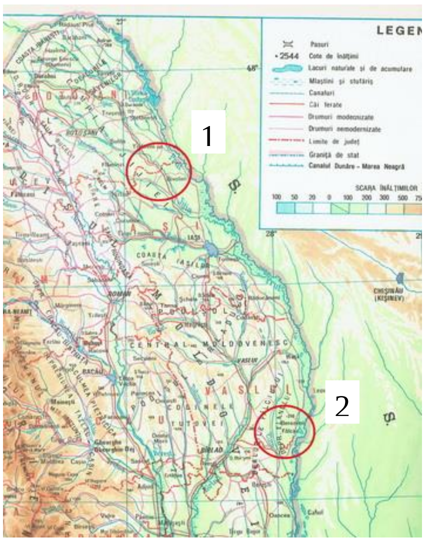


Figure 2 **Areas of study and research: 1 - South Soloneţ irrigation system; 2 - Albiţa Fălciu Complex Irrigation and Drainage Development**.

The research method is similar to that of technical expertise for irrigation systems. The field research analyzed the structural and functional state of the components of the irrigation system with influence on water losses.

Through documentation, the state of the structural components was analyzed based on known and accessible data. For each irrigation system, the initial topographic plans were used, but also those updated at the time of the research. The field research took photographic surveys and video images.

The data processing followed the methodology used in the technical and scientific analyzes developed for irrigation systems with transmission and distribution networks from canals and pressure pipes. The primary data collected were processed through specialized analysis programs in the field of irrigation research.

RESULTS AND DISCUSSIONS

The initiation and evolution of water losses in the structural components of irrigation systems are generated by natural and anthropogenic risk factors. Risk factors are generated from the design and execution phases. Also, water losses can be generated by new risk factors that appeared during the operation phase of the irrigation system.

The risk factors that initiate and develop water losses in the structure of the irrigation system come from the following situations (Luca M., 2020; Chirica Ș., Luca M., 2017):

- the quality and the way of elaborating the design studies (topographic, geotechnical, hydrogeological, climatic, seismic, etc.); the quality of studies is dependent on the professional quality of the staff of the company that elaborates the studies;

- technical quality of the project at various stages of implementation (feasibility study, technical project, execution details, specifications, etc.); the technical quality of the project must be correlated with the professional quality of the design team for the components of the irrigation system;

- natural and anthropogenic risk factors are introduced in the design stages through the activities: a - analysis of the geo-physical data of the site; b - designing the structure of the irrigation system; c - definition of flows, pressures, water heights in canals; d - choice of materials and technologies for the execution of water transport and storage components; e - calculation of constructive and functional parameters, etc.;

- the professional quality of the execution team highlighted by the materials and technologies of execution of the system (installation conditions for pipes and channels, the quality of joints and joints, the waterproofing technology of channels and basins, etc.);

- the professional quality of the operation team of the irrigation system highlighted by the management of water losses (detection method, equipment, monitoring methods, intervention measures, etc.);

- the management of the user of the irrigation system through the characteristics of the exploitation process, with reference to the rehabilitation and modernization works of some components of the system.

Water losses in irrigation systems are composed of the following components (Blidaru V. *et al*, 1981, Stăncescu L. *et al*, 1984):

- evaporation losses at the water surface, E_v (mm), expressed by the relation:

$$E_v = 15R_o d_u(1 + 0{,}20V_v), \quad (1)$$

where R_v is a correction coefficient; d_u - moisture deficit, in mm Hg; V_v - wind speed, in m/s;

- water losses by evaporation produced on the network of canals and in suction, discharge, storage tanks; q_{ev} (m^3/s); they are calculated with the relation:

$$q_{ev} = 0{,}001E_v S_e, \quad (2)$$

where S_e is the surface of the water gloss of the canals / basins, in m^2; E_v - value of 5-10% of evaporation losses, in mm;

- water losses in the system operation process, q_{ex} (m^3/s); they are produced by water emissions from the network of unused canals and pipes and volumes; operating losses are assessed in relation to:

$$q_{ex} = \frac{N_u + V_r}{T_p} + q_v L_v, \quad (3)$$

where N_u is no number of waterings during the vegetation period; V_r - the volume of water left unused on the network at a single watering, m^3; T_p - during the vegetation period, in s; q_v water losses caused by leaking valves, in m^3/s/m; L_v - the length of the wet perimeters of the taps, in m;

- water losses produced at hydraulic installations, especially at taps and hydrants, q_v (m^3/s/m); these were evaluated by research at values of 0.0001 - 0.0002 m^3/s/m depending on the quality of the sealing works; losses are valued with empirical relationships, or assimilated with similar relationships; the structure of the calculation relationship is:

$$q_v = f\,(l, d, s, p, \ldots), \quad (4)$$

where l is the length on which the water emission takes place; d - diameter; s - the size of the emission space; p - service pressure;

- water losses by infiltration from unlined or lined canals, but with significant degradations of the waterproofing layer located on the perimeter of the canal, q_i, (m^3/s/m); infiltration losses are evaluated with relationships obtained through research and have the following form:

$$q_i = f\,(l, b, m, h, k, B, \ldots), \quad (5)$$

where l is the infiltration length; b - the width of the bottom of the channel; m –the slope coefficient of the slope; h - water depth; k - hydraulic conductivity of the land; B - width of water gloss, etc.; in the specialized literature are presented relations and calculation diagrams.

In the sprinkler irrigation plots, water losses are allowed according to the values imposed by the operating norms. The value of losses is specified according to the place of production and limited to the following values (Stăncescu L. *et al*, 1984):

A - Characteristics of the irrigation plot (ISPIF, 1987a):

- branched pipeline network consisting of main pipelines - CP, secondary pipelines - CS and tertiary pipelines - A:

- central type pumping and pressurizing station (SPP);

- single-wire pumping and pressurizing station (SPPM);

- watering equipment for sprinkler watering.

B - Allowed values (percentages) for water losses from the total volume of water transported (Stăncescu *et al*, 1984):

- in the pipeline network about 5%;

- in the supply channel protected with a waterproof clothing about 5%;

- when watering in the field about 10%.

The degradation of the network of pipes and canals within the irrigation system initiates and develops large water losses. This situation determines the progressive increase of the number of damages and the increase of energy consumption (Cismaru V., 2004; Luca M., 2012, Luca M., 2020).

Water leaks from an irrigation system can be present in the following forms:

- substantive losses that occur in the operation of the structural components of the system in the operation process;

- unavoidable / planned losses in the operation process (e.g. emptying the pipeline network);

- diffuse water losses, which manifest themselves in the forms:

a. losses through pores formed in the pipe wall made of various materials (steel, cast iron, reinforced concrete);

b. losses through microcracks/small cracks in the wall of PVC, HDPE, cast iron, composite materials, etc .;

c. losses at the fittings for joining the pipe sections (elbows, branches, reductions, special parts, etc.);

- concentrated water losses, which are manifested by the forms:

a. losses caused by damage through cracks, breaking areas, material ruptures, etc.;

b. losses arising from the expulsion of the gasket at the connection of the valves, fittings and equipment in the hydraulic installation mounted in the manholes of the pipeline network;

c. losses occurring at the joint of the pipe sections, fittings and fittings in the hydraulic installation mounted in pumping stations;

e. losses formed during the total degradation or blockage of the hydraulic shock protection installations within the pipeline network and of the pumping stations (installations for aeration, hydraulic shock, emptying, etc.);

e. losses formed at the total degradation of the canal structure by breaking it, spilling the canopy, blocking the canal protection installations (eg clogging of the siphon spill).

Water losses are initiated and evolve over time in the structure of each component of the irrigation system. Water losses can be classified according to their position:

1. Losses from "water abstraction" from the source, determined by the structural condition of the intake constructions, the hydraulic installation and the take-up / pumping equipment.

2. Water losses caused by the state of the constructive structure of the “pumping / re-pumping station” on the supply and distribution route; losses occur at suction and discharge tanks, in the hydraulic installation, in the protection equipment, etc.

3. Water losses produced by the constructive structure of the supply and distribution channels made of earth or waterproofed with various materials.

4. Water losses produced by the components of the pipeline network with the role of supply and distribution to the irrigation plots. The leaks take place through the pipe wall, at the joint of the pipe sections, at the hydraulic installation in the manholes, etc.

5. Water losses produced by the constructive structure of the pumping station infrastructure (suction basin, wet tank, manholes with hydraulic installations, etc.).

6. Water losses produced by the components of the hydraulic installations in the irrigation plots (network of pipes, hydrants).

7. Water leaks caused by watering equipment components.

Limiting the water losses produced in the components of the irrigation system require a series of measures and rehabilitation works. These may include:

- periodic inspection of the structural state of the components of the irrigation system to highlight water losses;

- monitoring the volumes of water taken from the source, stored in canals and pipe networks, as well as drawing up a balance of the volumes of water consumed and lost;

- regular inspection of hydraulic drainage, overflow installations and of the separation and control valves on the pipelines;

- regular inspection of hydraulic protection installations (overflow-siphon), bypass dam, automatic control dam on channel networks.

Water loss management must consider the temporary mode of operation of the irrigation system. Irrigation systems in Romania have a functioning for certain periods of time (spring, summer and autumn), after which they enter conservation (winter and part of spring / autumn). When the operation process is interrupted (usually in autumn), the network of pipes and canals is emptied, a situation that determines a planned water loss. Water loss management also means reducing troubleshooting times, identifying flow areas and limiting the amount of water lost (Chirica Ș., 2019).

The network of pipes within an irrigation system is made with materials that respect the characteristics of the site (external loads, aggressiveness of the terrain), physical and chemical parameters of the transported water (temperature, clean or alluvial water and chemical conductivity) and hydraulic parameters (flows, speeds, pressures). The type of connection of the pipe sections is a main factor in the formation and evolution of water losses. The components of the joints, which structure and achieve the tightness of the pipe, withstand mechanical actions, degradation and aging phenomena over time (ISPIF, 1987b). These actions cause displacement and expulsion of the joint material.

Degradation over time of the joint between the waterproofing tiles of the channels, as well as the cracking / cracking of the tiles determines the appearance of water losses.

Physical water losses have existed in all the structural components of the irrigation system since its inception. They are classified according to their type and size:

1. Visible water losses, where they occur at or to the surface of the land and can be located immediately. Visible water losses are caused by the following situations:

- damage to the pipes or to the joints of the pipe sections;
- structural degradation of hydraulic installations in manholes with taps and pumping stations;
- structural degradation of hydraulic installations in pumping stations;
- structural degradation of irrigation hydrants;
- degradation of the waterproofing layers made on the perimeter of the canals;
- structural degradation of canals made in embankment and semi-embankment.

2. Hidden water losses, which do not manifest themselves on the surface of the land and are difficult to detect. These are caused by the degradation of the structural elements of the components of the irrigation system below the ground surface. Hidden water losses are caused by the seepage of water from the canals, the seepage from the suction and discharge basins, the degradation of the plugs at the irrigation pipes, etc. The detection of these losses involves special measurements and equipment for their detection.

3. Substantial losses, which occur with low flows from the underground infrastructure of the irrigation system. These losses cannot be detected using current technical methods.

The studies and researches carried out within the "Complex Management of Irrigation and Drainage Albiţa Fălciu", in the "Irrigation System North - Soloneţ" and "Irrigation System Terasa Brăilei" highlighted the presence and special influence of water losses on the exploitation yields of the channels and pipes (Luca M., 2012, Luca M., 2014; Luca M., 2015; Luca M., 2016; Luca M., 2020).

The research carried out in 2019 in the "SPP 8 Oţetoaia Irrigation Plot" and the "SPP 9 Oţetoaia Irrigation Plot" from the Albiţa Fălciu Irrigation System (*figure 2*) highlighted the following very high water losses (Luca M., 2020):

- water losses on the adduction channel network (AC and CD) of the pressurization stations (SPP) produced by the advanced state of degradation of the constructive structure: degradation of the joint between the concrete slabs; breaking and moving the tiles on the slope, washing the support layer of the tiles, compacting the slope from the ground, etc. (*figure 3*); the value of water losses is estimated at about 35% - 45% of the volume of water introduced into the canal;

Figure 3 **The state of degradation of the canals in the SPP Irrigation Plot 8 Oțetoaia with factors to increase water losses (Luca M., 2020)**

- water losses on the pipe network of the irrigation plot (main pipes - CP, secondary pipes - CS and tertiary pipes - A); the main pipes made of steel were degraded by chemical corrosion on some sections, a situation that caused large water losses (*figure 4*); the water losses evaluated on the main pipe are about 17 - 24% of the pumped flow, a situation that determined the replacement of the degraded sections.

Figure 4 **Degradation status of the main steel pipes in the SPP Irrigation Plot 8 Oțetoaia with water loss increase factors (Luca M., 2020)**

The absence of the complete rehabilitation of the pipeline network determines the intensification of water losses on the old pipeline sections, which have exceeded the operation period. The absence of the rehabilitation of the manholes on the network of pipes, constructions and hydraulic installations, determines the increase of the number of damages and implicitly of the water losses.

The problem of water losses in the pressure pipelines (P = 6.0 - 8.0 bar) in the irrigation plots must be considered in the rehabilitation process.

Water losses influence the efficiency of the pipeline network and implicitly the operating efficiency of the irrigation plot.

The efficiency of the pipeline network for the case of current operation can be determined by the relationship (Stăncescu L. *et al*, 1985):

$$\eta_c = \frac{\alpha * Q_{inst} * T_1 - \sum p_l * T}{\alpha * Q_{inst} * T_1} * 100 \ [\%] \qquad (6)$$

where: α is the ratio between the average daily flow achieved and the installed flow at the SPP; Q_{inst} - the installed flow of the SPP; p_i - the sum of water losses in the irrigation season (percentage of the total volume of water pumped); T_1 - number of days of operation of the SPP; T - the duration of the irrigation campaign in which the network was full of water.

In order to identify and remedy the defects that have appeared in the irrigation systems, a series of specific steps are taken in this field. The first step is to define on the ground the sectors of the canal or pipeline networks are water losses. Each sector is divided into mini-sectors on distinct structures (canal sections, pipe sections, hydraulic installations in manholes, etc.). In the second stage, a system of permanent monitoring of the mini-sectors with water losses is realized. In the third stage, the areas with losses are located and their cause is defined: damages, disturbances, advanced wear of the components, exceeding the functional parameters (flows, pressures, water heights), etc.

In the third stage, the way of tracking the losses, measuring the parameters and making remedial decisions is initialized. All the basic data of the components of the irrigation system, the history of damages on structural components, functional parameters, the value of water losses, remediation works, etc. are introduced in a monitoring program. The Land Improvement Administration must be equipped with a department specialized in the field of water loss monitoring. This department must be equipped with equipment and qualified personnel for this very important field in water management in the transmission and distribution network of the irrigation system. The management of water losses in the network of canals and pipes of the irrigation system can also be performed by specialized companies (Cassa A.M. *et al*, 2010).

Through the process of monitoring the sectors and mini-sectors, a series of data is obtained, which establish the investigation areas in detail for the identification of defects on the network of channels and pipelines (Chirica Ș. *et al.*, 2018).

In the third stage (location of damages / defects) the search area for structural defects is restricted by using equipment and devices to indicate possible losses. Among the most used equipment are noise loggers.

Water leaks from the pressure pipes cause vibrations in the pipe walls (*figure 5*). These vibrations can be recorded with the help of loggers. The equipment detects both the noise produced by the fault and the frequency. Based on these factors, the probability of a network fault can be determined, as well as its relative position in relation to other loggers mounted in the system (Chirica Ș., 2019).

Figure 5 **Noise loggers for monitoring and acoustic detection of water leaks in pipes (Chirica Ș., 2019)**

Loggers record the sounds produced on the network by the presence of water emission zones. The loggers are mounted on different areas of the inspected pipe sector. so that the result is not influenced by other noises. Depending on the values obtained, it is established whether detailed investigations are necessary or another area is inspected.

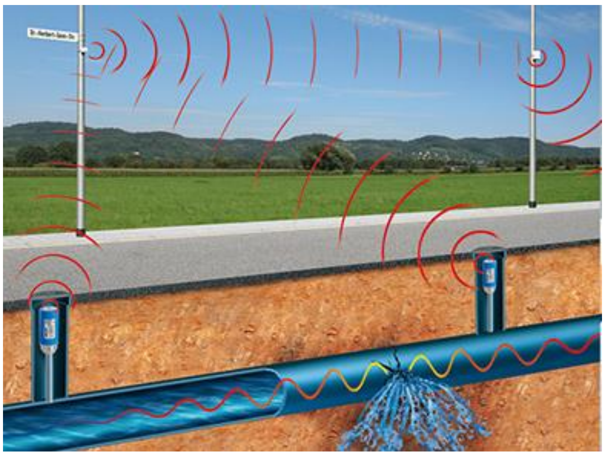


Figure 6 **Flow and pressure loggers for monitoring and acoustic detection of water leaks in pipes (Chirica Ș., 2019)**

It is widely used by flow and pressure loggers, which are robust and compact devices that are mounted on the pipeline network (*figure 6*). They transmit information about the flows and pressures in the water supply pipes. The equipment can be equipped with alarm systems, which signal to the operator in real time the appearance of significant changes in the values of flows and pressures (Chirica Ș., 2019).

After the restriction of the inspection area, the location of the damages is done by using acoustic and non-acoustic equipment. The most used acoustic equipment is the type of ground microphones and noise correlators. Non-acoustic equipment involves the use of a tracer gas or georadar.

Acoustic monitoring of the network can be permanent, by installing a network of loggers to transmit data daily, or occasionally, when flow measurements show the existence of a fault on the network. The main advantage of using a network of loggers is the reduction of fault location times, thus minimizing lost water volumes.

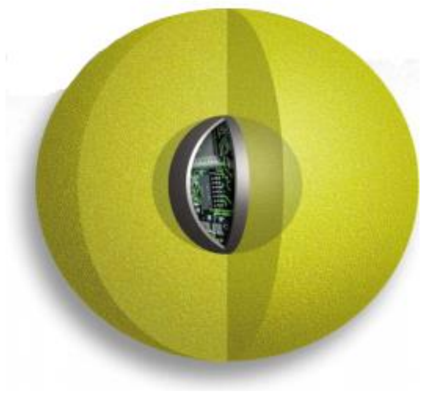
Ground microphones are mechanical or electronic equipment (*figure 7*). Microphones use sound amplification devices produced by vibrations caused by damage to pipes. The microphones have noise filtering devices so that the recorded results are relevant to the leak detection activity. The efficiency of the investigation method is largely based on the professional experience of the operator.

a b

Figure 7. **Ground microphones: a - equipment with digital signal processing technology; b - equipment with integrated sensor (Chirica Ș., 2019).**

A state-of-the-art technology is "Smart Ball", which determines the noises produced by the phenomenon of "water loss" in a working pipe. This technology uses a polyurethane foam ball with an aluminium core in which a sensor is inserted to detect noise from water leaks in pipes (*figure 8*).

The detection sensor is inserted into the pipe through an access point and extracted through another pipe control point. The sensor floats freely along the pipe and collects data on the functional state of the pipe. The technology can record the collected data for up to 12 hours. After completing the preset route, the sensor is removed from the pipe using a recovery net. The collected data is processed and centralized in the pipeline network monitoring program.



a

b

Figure 8. **Technology for detecting water loss from Smart Ball pipes: a - section through the parameter detection sensor; b - complete water loss detection equipment (Chirica Ș., 2019).**

For the investigation of old pipelines and in the absence of initial situation plans, the "Georadar" can be used (*figure 9*).

Figure 9. **Pipe detection equipment type Georadar**

Georadar uses radio waves (electromagnetic waves) to investigate construction elements and underground installations. The technology has been adapted to locate water leaks in buried pipes and investigate the condition of underground networks. Leaks are identified due to differences in the density of the land in which the pipes are embedded and its water content.

The penetration power of the equipment depends on the length of the radiation wave and the electrical permittivity of the rock in the site. The use of this technology requires knowledge of the geotechnical properties of the site and especially its electrical conductivity.

Water loss detection can be done with the help of satellite technology (Ganea D., 2015). This is based on the identification of the spectral footprint of water. Satellite-mounted sensors identify water leaks from a pipeline network. The main advantage of this technology is the ability to obtain information on the entire operating system with a single use. Satellite detection covers areas of thousands of square kilometres and indicates the position of losses in an area with a diameter of 6 meters.

CONCLUSIONS

1. Water losses have been present since the establishment of the irrigation system, and their value varies over time depending on the technical characteristics of the operation process.
2. The irrigation systems in Romania, which are still in operation, have a long service life, and the absence of maintenance and rehabilitation works of the network of canals and pipes has determined the progressive increase of water losses.
3. The irrigation systems analyzed in the eastern part of Romania show background water losses from the supply and distribution channels due to their structural degradation.
4. The field analysis revealed significant background water losses to the system's supply pipes, as well as to the network of pipes of the irrigation plots due to exceeding the service life of the execution material.
5. At the present stage, a system for tracking water losses must be developed with the use of modern reversal technologies and monitoring programs over time.
6. Water losses adversely affect the hydraulic efficiency of the components of the irrigation system, energy costs and in general the operating costs of the irrigation system.

REFERENCES

Blidaru V., Pricop G., Wehry A., 1981 - *Irigaţii şi drenaje*. Ed. Did. ;i Pedag., Bucureşti

Cassa A.M., Van Zyl J.E., Laubscher R.F., 2010 - *A numerical investigation into the effect of pressure on holes and cracks in water supply pipes*, Urban Water Journal, 7(2):109 – 120.

Cazacu E., Dorobanţu M., Georgescu I., Sârbu E., 1982 – *Amenajări de irigaţii*. Edit. Ceres, Bucureşti.

Cismaru C., 2004 – *Irigaţii: amenajări, reabilitări şi modernizări*. Ed. Politehnium, Iaşi.

Chirica Ştefania Luca M., Lateş Iustina, 2018 - *Updating the pipe networks layout plan using modern detection equipment*. Bulletin of the Polytechnic Institute from Iaşi, Tome 64 (68), No. 2, Section Hidrotechnics, Edit. Politehnium, p. 17-26.

Chirica Ştefania, Luca M., 2017 - *Studies and research on pipe networks water losses*. The Annals of "Dunărea de Jos" University of Galaţi, Fascicle IX, Metallurgy and Materials Science, 2:11-17.

Chirica Șt., 2019 – *Contribuții la cercetarea fenomenului „Pierderi de apă" din rețelele hidroedilitare*. Teză de doctorat. Universitatea Tehnică „Gheorghe Asachi" din Iași.

Ganea D., 2015 - *Geospatial methods using to establish the schedule for water leakages detection teams and apparent leakages determination*. Proceedings IWA Regional Conference: "Water Loss Management 2015", ARA Publishing, Bucureşti, Romania, pp. 297 – 304.

ISPIF, 1987 - Proiect nr. 4824-R - *Proiecte tip de construcţii pentru Îmbunătăţiri Funciare Catalog 4, subcapitolul Ploturi de irigaţie cu conducte sub presiune*, Bucureşti.

ISPIF, 1987a - Proiect nr. 4276, Proiect Tip Departamental privind Construcţii şi Instalaţii, Accesorii pe conducte de irigaţii sub presiune din beton armat, azbociment şi PVC, București.

Luca M., 2012 - *Expertiza tehnică a Staţiei de pompare SPP 1b din obiectivul de investiţii „Modernizarea si retehnologizarea staţiilor de pompare pentru irigaţii a Aqua Soloneţ Nord Bivolari, judeţul Iaşi*. S.C Polias – Instal S.R.L. Iaşi.

Luca M., 2015 - *Expertiză tehnică „Modernizarea si retehnologizarea sistemului de irigaţii la O.U.A.I. Agro Irig Prut Berezeni", jud. Vaslui*. S.C. Polias-Instal S.R.L. Iaşi.

Luca M., 2016 - *Expertiză tehnică „Modernizarea si retehnologizarea sistemului de irigaţii la O.U.A.I. Doniceasa-Fălciu", jud. Vaslui*. S.C. Polias-Instal S.R.L. Iaşi.

Luca Al., L., Luca M., Juncanaru Oana-Ştefania, Ilie G., 2016 - *Considerations on rehabilitation of irrigation sprinkler plots - rehabilitation of the pumping stations*. Lucrări Ştiinţifice. Seria Agronomie, 59(1):117-120.

Luca M., Luca A.L., Marcoie N., Logigan I., **2017** - *The rehabilitation of pipe network from sprinkler irrigation plots*. Lucrări Ştiinţifice. Seria Agronomie, 60(1):43-48.

Luca M., 2020 - *Expertiză tehnică „Modernizarea si retehnologizarea sistemului de irigaţii la O.U.A.I. Oțetoaia", jud. Vaslui*. S.C. Polias-Instal S.R.L. Iaşi.

Stăncescu L., Moraru N., Ionescu V., Leinweber L., **1984** - *Îndrumător tehnic pentru lucrări de îmbunătăţiri funciare*. Edit. Ceres, Bucureşti.

*** **HGR 766/1997** – Regulament privind urmărirea comportării, exploatarea, intervenţiile în timp şi postutilizarea construcţiilor. Monitorul Oficial, Anul IX, nr. 352. 788.