THE PARAMETERS DETERMINATION PROBLEM OF THE SEWAGE SYSTEM FUNCTION

Vladimir Patrčević[1], Siniša Maričić[2] and Tatjana Mijušković-Svetinović[3]
[1,2,3] Faculty of civil engineering University of Osijek, Drinska 16 a, 31 000 Osijek, Croatia
[1] E-mail: vladimir.patrcevic@zg.tel.hr
[2] E-mail: smaricic@most.gfos.hr
[3] E-mail: tatjanam@most.gfos.hr

Abstract: The urban sewage systems usually have no preventive development. The social development exceeds the urban sewage development, and urban sewage system is frequently overloaded and we don' t know how the system exactly functions. The attempt to determine the real condition parameters, in purpose to model and to plan the further urban sewage system development is followed by many problems. The aim of this paper is to point out some concrete problems on the example of the city of Osijek and its sewage system.

Osijek is the center of the region where the city itself has more than 100 000 inhabitants. The good watersupply development wasn't successfully followed by the sewage system development. The new main sewer has been under construction for the last 30 years so it is no wonder that the wastewater treatment plant is something that people have just started to think about. The experts have got the task to model the current condition and this model will be the base for modeling and planning the future conditions. Following this, precipitation monitoring and flow monitoring in the sewage system are installed in the area of Osijek. Five rain gauge stations are established. Discharge is measured on six gauge stations, and measurements are also established to define storm overflow. The experiences collected in this paper can be useful to the others in similar circumstances.

Keywords: *sewage system, precipitation, flow, monitoring, modeling*

DIE PROBLEME BEI DER BESTIMMUNG DER FUNKTIONSPARAMETER IM KANALISATIONSABWASSERUNGsSYSTEM

Zusammenfassung: Die Entwicklung der Urbanwasserableitung geschieht meistens nicht präventiv. Sie wird von allgemeinen Gesellschaftentwicklung übersteigt und das Kanalisationsabwasserungsystem ist oft überlastet und man weiss nicht genau wie es funktioniert. Die Feststellung des tatsächlichen Zustands, um die weitere Entwicklung modelieren und planen zu können, wird von mehreren Problemen gefolgt. Die Absicht dieser Arbeit ist, auf dem Beispiel des Kanalisationsabwasserungssystems der Stadt Osijek, auf einige von diesen Problem hinzuweisen.

Osijek ist ein Mittelpunkt mit über 100.000 Einwohner (die Stadt selbst). Die gute Entwicklung der Wasserversorgung wird nicht von auch so einer Entwicklung des Abwasserungsystems gefolgt. Der neue Hauptsammler wird seit 30 Jahren gebaut und es ist kein Wunder das man sich über einer Kläranlage zur Zeit nur Gedanken macht. Vor dem Fachexperten befindet sich die Aufgabe der bestehende Zustand zu modelieren als Grundlage für die Modelierung und Planung der zukunftigen Zustände. In diesem Sinne ist die Niederschlags- und Kanalisationsableitungmonitoring aufgestellt. 5 Ombrographsstationen sind aufgestellt, an 6 Stellen wird Durchfluss gemessen und es werden Messungen unternommen, die die Abläufe über Regenüberläufe definieren sollten. Diese Erfahrungen können dann auch anderen in ähnlichen Umständen helfen.

Schlüsselwörter: *Kanalisationsabwasserungssystem, Niederschläg, Abfluss, Monitoring, Modelierung*

1. Introduction

There are a few cities which were developed in the last century and whose development was strictly planned. Most of them were built up during the centuries and developed by different intensity. The urban sewage system became a very important part of the city development. The development of the sewage system was initiated by the achieved level of the general society development – higher standard or by bigger problems (frequent infections, epidemics, falling in etc.) – emergency. The system is planned for some time in advance but it is limited by the available amount of money. It is the usual case that the reconstruction and/or building of sewage system don' t have preventive development. The urban communities come to decisions about the investment in something else easier. It comes to the progress only when the existing sewage system cannot satisfy the higher needs that result from the general society development. The increased number of the connections, higher water consumption and the extention of the basic sewage system network cause to the sewage system overloading. That is usually the moment when we realise that we don't know how the system exactly functions. For the further sewage system development it becomes very important to perceive the existing condition and the frames of the future development.

Today development of the sewage systems is based on modelling their functioning. The complex mathematical models are used which include hydrologic-hydraulic, topographic-geodetic, physical, planned and other parameters of the analysed system. The modelling itself requires not only the knowledge of the complex mathematical model which is in use but also the adequate preparation skill and the data input skill. Data input quality and quantity are crucially important for the value of the finally created model of the sewage system.

2. Sewage system of the city of Osijek

The city of Osijek lies on the Drava River. It has almost 100 000 inhabitants, and with suburbs nearly 120 000 inhabitants. The former development of the urban part of the city formed the elongated city shape along the right river bank. The elements of the old watersupply and sewage systems are still visible in the old part of Osijek –Tvrđa, where people try to preserve the old buildings by restoration. This system dates from the year 1758 and it is the third in the city. The first system was the one from the year 133 when the then Osijek – Roman Mursa was a very important city. The second system was developed during the Turkish rule (Turkish wells, fountains and baths are well known). The fourth was in public use from the year 1893, and the city's firemen held it. That system used the water from the Drava watercourse, and the city council took it over in the year 1937. Since 1984 the inhabitants of Osijek have used the water from the artesian wells. The need for building the underground sewage system culminated at the beginning of the 20th century. The basic sewage city network, based on the 30000 inhabitants was built from 1903 till 1914. Its characteristic were: it was elongated as the city itself; the main sewer (so called Northern) stretches along the river course; its character is heterogenous – it receives both rainfalls and city and industrial wastewaters. It takes the sewage water into the alive river course by rains overflow, which end on the right side of the river and by the main drain pipe. The drain pipe is downstream from the city on cca. 12,1 rkm, i.e. near the river mouth into Danube. Sewage system was developed by the upgrading of the secondary sewer network and by induction of the new connections. So, today there are over 17000 house (familiy) connections and group building connections, and there are about 60 so called industrial connections. At the end of sixties the need for modernisation of the system emerges. On the one hand they should solve the problem of the drainage for the numerous surrounding suburbs, which were in expansion, and on the other hand the basic city network was threatened to collapse. At the same time they were aiming at the purification of the wastewater to protect the environment, i.e. the water of the Drava River. The concept was then assimilated for the gathering of the wastewater from the wider territory and its purification in one place – the central wastewater treatment plant. The building of the new main sewer (so called Southern), which was on location for the wastewater treatment plant, began in the year 1969, and the other smaller sewers should have been connected to it. That sewer has not been finished till today. The huge works were done, but the economic condition in the society in the last years disables the final finish of this sewer. In spite of that, there are the efforts of the experts and local community organisation to develop the general sewage system. Except daily maintaining of the system the main Southern sewer has been slowly built. The effusion building is finished and the popular eco-laboratory is organized with the aim to examine the condition and the quality of the wastewater. In 1998 the project "Drainage model with the idea project for the sewage system of the city of Osijek" was started, but due to economic problems its realisation is late.

3. Determining the system functioning parameters

3.1. Sewage model of the city of Osijek

This project was started with the aim to determine the real condition (function parameters) of the sewage system of the city and to determine the need for the numerical modelling of this system by using some modern computerised program packet (mathematical model). Measurements in the system and fluxion modelling have the goal to identify the possibilities of the existing sewage network. It makes the base for the further performance of the Project, which includes the sewage system development planning. Within the further steps the modelling of the different varieties for upgrading the system is planned because of the fluxion regime determination. The achieved models will make the system managing simulation possible with the purpose to use their capacities for discharge of the wastewater treatment plant. So, we follow after the sewage system managing (quantity and distribution, as well as quality) and development optimisation. Therefore we need to observe the prerequisites for proper reactions in different hydrologic-hydraulic sewage regimes and to define the objects and instruments for permanent control establishing over the sewage system work. The following things should make it possible: system monitoring, relevant data collection and data processing and numeric modelling procedure.

3.2. Parameters determination activities for modelling

The first step of the project aims at getting the numerical model of the existing sewage system in the city of Osijek, which renders the fluxion through the sewage system in different, present, hydrologic-hydraulic conditions. Following this, a series of different activities was started, among them there are: GIS surrounding creating for different network data input. Collecting and processing of registrated hydrological-hydraulic river basin characteristics and detailed monitoring performing in the sewage river basin. The limiting element is the amount of money invested in these activities, which is in general always small.

Since the monitoring requires the exact observation time, its organisation began at once. The common decision was to get and use five ombrographs and six flow meters.
It is planned to do the modelling by using the well known model MOUSE 11.

The possible locations of measuring instruments placing were analysed with regard to the specific configurations of the Osijek's sewage system and according to the requests of the sewage system mathematics modelling. Among many microlocations more adequate locations were chosen according to the circumstances connected to the placing and controlling of the mentioned locations (the control and reading as well as the measuring instruments safety).

The picture 1 shows the urban city and the measuring locations. We aimed at the data representative quality in terms of system functioning, and the experiences of the long time worker of the sewage system (utility firm) were of the crucial importance. The problems of the property-legal relationships, bad conditions in sewage system (due to worn-out state), protection from the traffic, uncontrolled equipment touching, etc were observed. The measuring equipment SEBA-HYDROMETRIE was acquired from Germany. The characteristics of flow meter and ombrographs are shown in Table 1. Flow meters are conceived so that they measure water level and average water speed in measuring profile in programmed time interval and they calculate on the basis of the known profile geometry the flow through i.e. the amount of water drained off by the sewer. The parts of the instruments and the way of placing are given in the picture 2. In the first calibration steps the pipeline profile geometry and adopted measuring time interval are entered in the memory of the particular flowmeter. The water level measuring is calibrated first and after that the fluxion calculation with regard to the static alluvium on the pipeline bottom. After a few work controls the measuring place is in operation with the continuous digital recording of the measured water level, speed and calculated fluxion.

Electronic rain gauges – ombrographs are characterized by automatic work and continuous measuring. They enable the data collecting about rainfall quantity in space and time. The used ombrographs record digitally time and growth of the total rainfall event in form of rainfall impulses accuracy from 0,1 mm (volume of the measuring container on seesaw). By using the digital records of the recorded rainfall impulses, all other parameters are calculated (total quality of rainfall event in a period of time, shower intensity, shower development phases, statistic parameters of the registrated rainfall events i.e.) For the ombrograph placing the special carriers for any particular situation were made. Some of the placing ways and instrument parts are shown in picture 3.

Communication with the measuring instruments memory and data reading are done by lap-top.

Table 1. The characteristics of flow meter and ombrographs

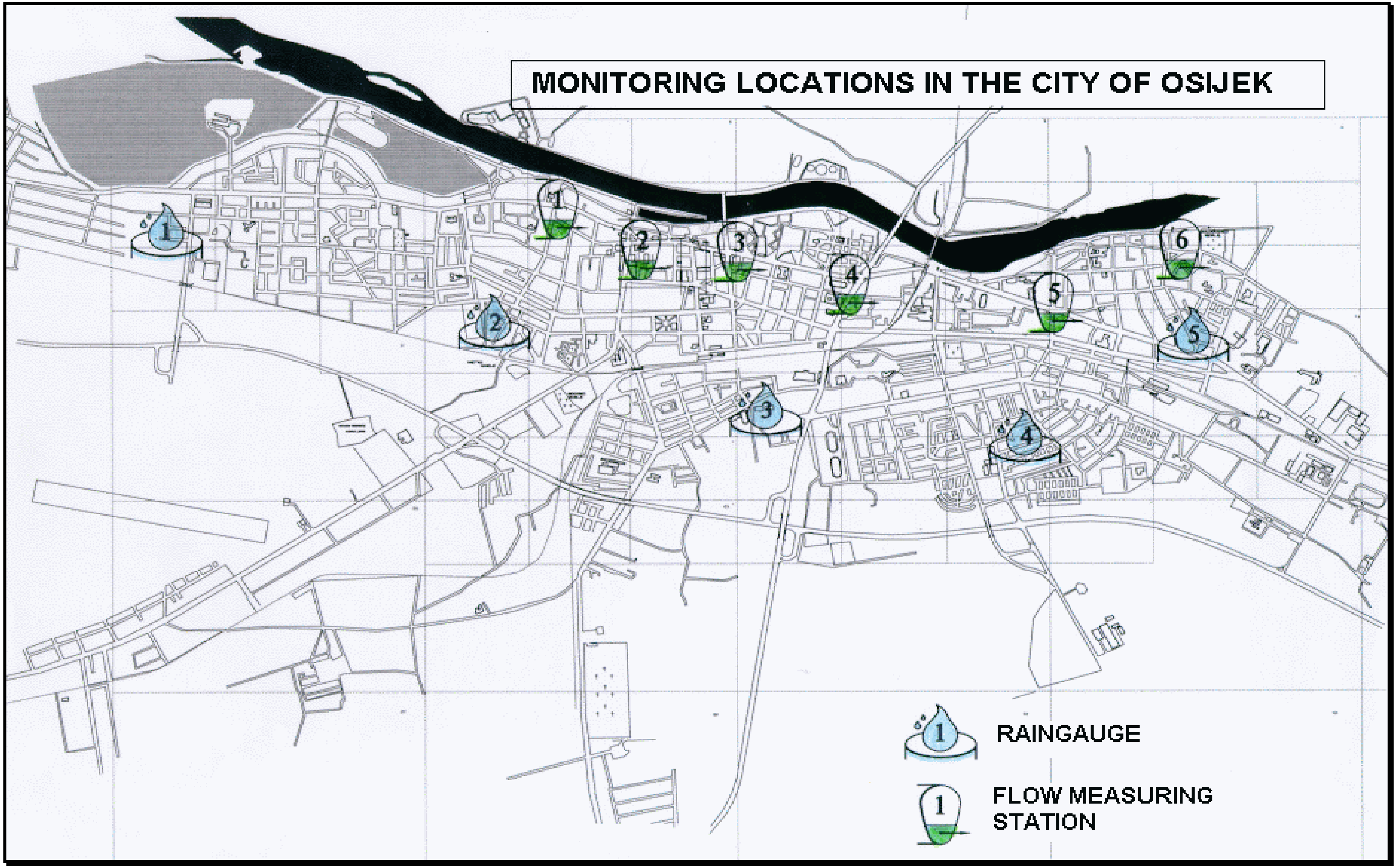
CHARACTERISTICS	***FLOW METER***	***OMBROGRAPHS***
TYPE	SEBA 910	SEBA RG-50
PARTS	SENSOR, MEMORY, BATTERY, CABLES	FRAME, CYLINDER, MEMORY RDS I, HOPPER, AUTOMATIC MEASURER
MAIN DIMENSIONS	2X3,8X12,7(SENSOR); l=44,8cm; D= 11,4cm; (BATTERY) 3,54 kg	D=20,5 cm, H=34,6cm; (HOPPER) D=16cm; G=3,9 kg,
SPECIAL CHARACTERISTICS	-18^{o} - +60^{o}C; 6 V; DOPPLER'S EFFECT	MILNE'S CONTAINER; 0,1 mm RAINFALL; 200 cm^{2} AREA

3.3. Monitoring experiences in the sewage river basin of the city of Osijek

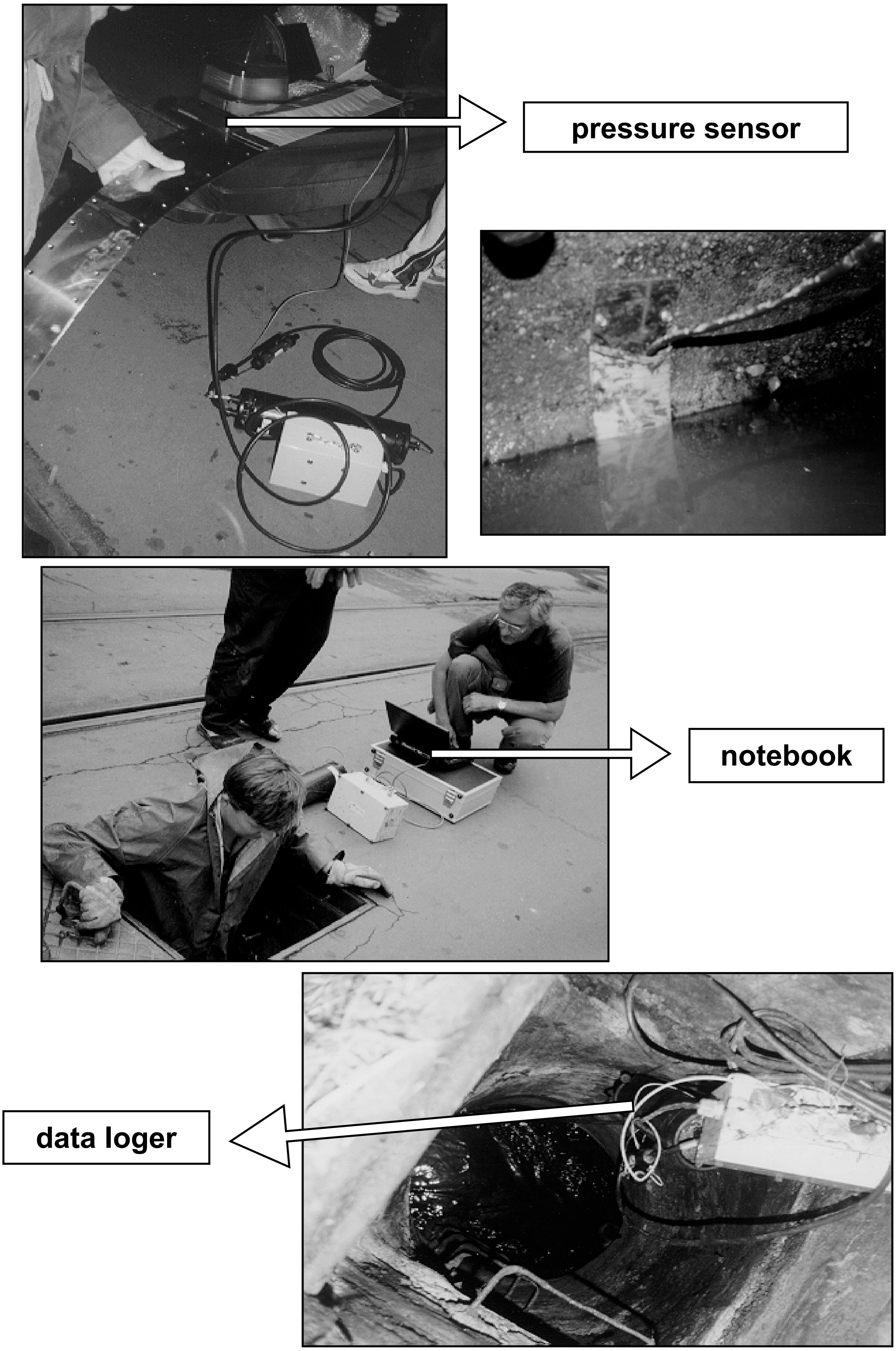
Rainfall and drainage monitoring in the river basin of the sewage system of the city Osijek was foreseen in duration of four months. Due to smaller problems (primarily measuring interruptions – data losing on some locations) but also due to higher interest for data quality the measuring lasted longer from May 1999 till October 2000).

The first problems appeared with preparing and organizing measuring locations. Namely, the way of setting the equipment in the working position should have been theoretically organized. It included the idea, construction, schemes, making and proper building of adequate carriers. The simple metal carriers were used which were attached to the throat of the sewage shaft. Such carrier can be made quickly and cheaply and it has all necessary working advantages (the equipment can be locked, it is accessible and easy to use, there is only slight obstacle when entering the shaft i.e.). For attaching of the underwater equipment parts (sensor) the manufacturer used special carrying metal plates.

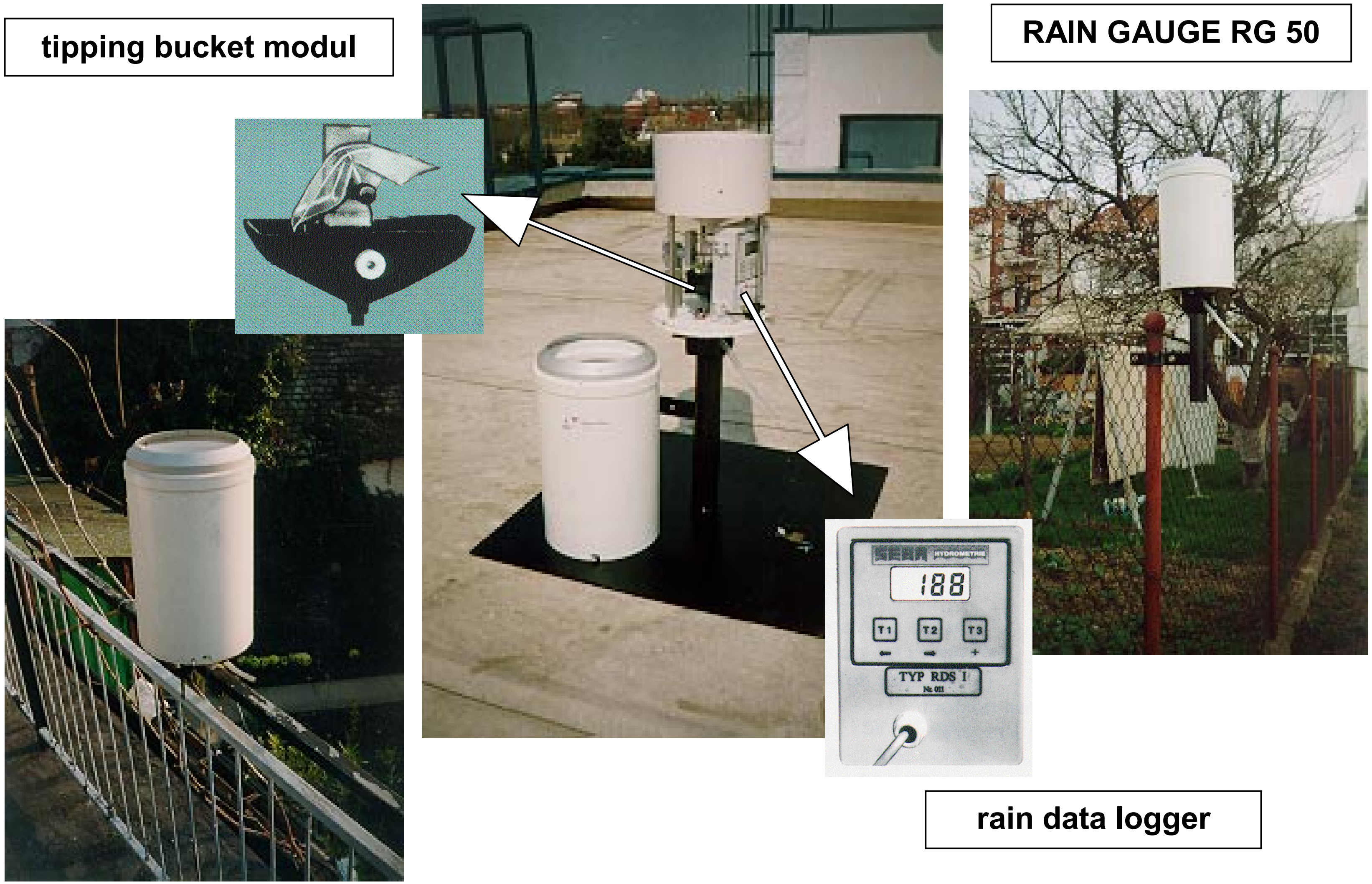
When building the equipment, the problem was in foreseening all possible circumstances connected to the shaft environment protection and to working conditions in the sewage inside. Concretely, traffic signs and warning and ban equipment were planned and used, as well as the instruments for the valuation of sewage gases condition, the other tools were prepared in advance – bucket and hook on the rope, petrol generator, extended cable with the fuse, lighting lamp, tools, i.e. The significant presence of the dangerous gases in the sewage system was not registrated and therefore there was no need for protection in that sense. The building was done during the night between 3^{00} and 5^{00} o'clock, when the traffic intensity was low and the water level in the sewer network was minimum.



Picture 1. Rain gauge and flow measuring stations in the city of Osijek area



Picture 2. The parts of the instruments for flow measuring and the way of placing them in the manhole



Picture 3. Rain gauges, instrument parts and some of the placing ways

On one location there was a pipeline profile (round d=93 cm) different from the one previously placed (oval 75/110 cm) on the basis of archival materials. The Drava River influence on the drainage was estaclished on the location which was the most downstream. The total deficiency of the fluxion profile happened there more often as well as the significant loading by the suspended and flowing industrial wastwater alluviums. Therefore that measuring place was controlled more often. The deficiency circumstances of so big profile make impossible the accumulation removing (paper, cloth, plastic, plant i.e. origin) from the sensor. The probability for data non-collecting will be in these conditions higher. Because of the mentioned sensor functioning interruptions due to accumulation gathering the more often controls and cleanings were organized. We aimed at one control a week, but there were also exceptions (sometime more than once a week and sometime less).

The further problem was wrenching out of the screws from the pipeline wall. When building, the relatively short metal screw anchor and special beating screws were used. They enable fast building of the carrying metal sheet in unfavourable working conditions. But because of the lower concrete quality in the upper surface layer of the pipeline and due to metal sheet vibration during great water flowing through, it came to the concrete decay around short screw anchor. Exactly that happened on some locations. Wrenching out was due to often controls observed in time and the improvement was quick so the further damages were avoided. Some damages can be seen on enclosed picture 4.

The problem of collector battery emptying appeared. Namely, the batteries are activated during the automatic contact between collector and sensor

Since the interval between consecutive contacts is programmed during the collector starting, and battery duration (voltage sufficiency) depends on that data collecting density, it is clear that the battery empties faster if the data collecting is more frequent. Some other parameters empty the battery faster, for example working area humidity, the length of the connecting cable, i.e. For the beginning the data collecting interval was programmed in (short) time of 5 minutes. Therefore the battery voltage empting was quickly noticed and the new batteries were bought so that the measurement was not interrupted. Since the time for supply is needed, the reading was programmed more rarely (every 15 minutes). If the collector memory is not read and reset in time, it comes to the situation that the memory is full and the oldest data get deleted (overrecording). It means the irreparable loss of the registrated data.

Beside all caution the accidents happen. During this monitoring, a tram caught the shaft cover which broke off and crushed the battery box. Due to relatively frequent measuring location controls the monitoring workers and traffic participants got used to each other. It brought to the lower attention level. In these circumstances the tram driver hurried (because of the previous traffic jam) when he was passing the measuring location. One tram had passed in front of him, and there were no problems in previous days, so everybody expected undisturbed passing. But this tram, which just started in traffic, was from different type, and it caught with the lower fender the shaft cover, which was raised and moved to the roadside. There were four persons at that time and fortunately nobody was hit by it. Neither were damaged parked cars, computerised equipment for reading nor battery and collector. Only the battery box was damaged completely. The other battery and collector were connected later and the further measuring location function was checked. The battery and connections were adequatly insulated and protected from the aggressive surrounding so that they lasted till the new battery supply.

The case of one ombrograph damaging was interesting too. We took care of the fact that the ombrographs were placed out of the curious persons' reach and that the ombrogrphs should be protected from the low (negative) temperatures. But the hail consequences could not be prevented. In one part of the city the very rare appearance of very big hail stones “in size of the child's hand” caused the unexpected damage. The big hail-stone hit and literally broke the collecting hopper of the ombriograph. The hopper was repaired by gluing and the temporary ombriograph work was possible till the supply of the new one. A few times the hopper throats were obturated which influenced the measuring accuracy. It was caused by the dead insect and the plant seed. Such negative effects could be reduced by often controls.

For the protection from the humidity penetration and its damaging effects there is the humidity anullator on the collector cable. The granulas Si_2O (so called sillicate) insure its function. Granulas colour is the indicator of the accumulated humidity and it signalises the replacement need. Humidity protection controls were done regulary and the replacement of the used granulas by the new ones was done in time.

One of the monitoring problems is occasional access impossibility to some measuring locations as well as the problematical condition of the climbing irons and covers of some shafts. These problems were often pointed out to the sewage workers but there were no results (they did not do anything about it). The worst access problem was at one shaft which was placed on the parking lot. The parked car exactly above the mentioned shaft was very often case. The occasional attempts to mark the shaft and warning signs did not give any results. Those signs were actually roughly removed. The access impossibility disturbed the control rhythm and data reading as well as the sensor cleaning. Incidental situations due to damaged climbing irons and shafts covers were during the monitoring fortunately avoided.

The research and the measuring elements of the rainfall overflow functioning started afterwards. The geometry was recorded in details and it was according to the functioning the most “suspicious” overflow. Electronic limnigraph SEBA –MDS Insider) was installed there and it recorded digitally the overflow level. On the basis of the recorded parameters the estimation of the overflow quantity was done. The conclusion was that the overflow happened in the dry periods (without rainfall events) too.

4. Conclusions

The improvement, reconstruction or development of the sewage systems is based today on the modelling of their function. The complex mathematical models are the most often used, which include the hydrologic-hydraulic, topographic-geodetic, physical, planned and other parameters of the analysed system.

The modelling of the combined sewage systems requires the knowledge of the complex mathematical models but also the proper preparation skill as well as the system functioning data input. The quantity and quality of the input data are important for the value of the assigned model of the sewage system, for the right decisions at system managing and for the technical procedures on system objects, all aimed at the optimisation.

It is important, for all that, to put the special emphasis on the quality of the hydrologic parameters measuring in the drainage system.

At the combined sewage system, which is in the city of Osijek, the most important hydrologic parameters are primarily rainfalls and drainage in the main sewer and the water level in the Drava River as the vital factor of the flowing non stationariness in the drainage sewer before it drains into the waterstream.

The right choice of the hydrometric equipment, measuring locations, the right building and work programming as well as the monitoring observation and control turned out to be very sensitive moments with great importance for the settled goals.

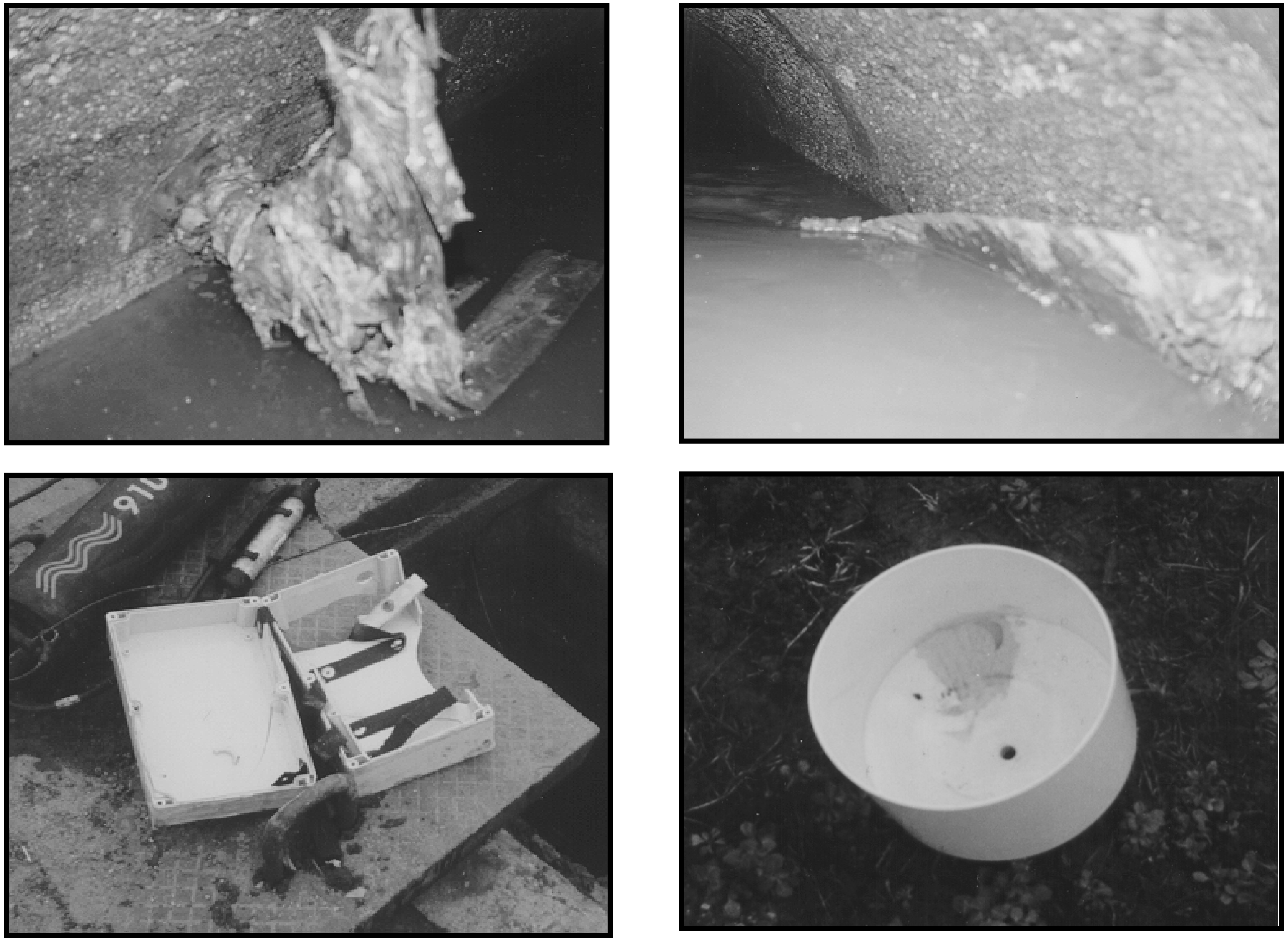
The experiences in monitoring of the rainfalls and drainage in the sewage river basin in the city of Osijek showed that it is necessary to have a lot of experience and luck to carry out the settled task well.

At the end it should be pointed out that it is important to choose the quality measuring equipment and the constant team for servising of the measuring equipment and the constant control of the measuring locations.

5. References

Čačić, Lj., Vouk, V. (1994.): Odvodnja i pročišćavanje otpadnih voda grada Osijeka, Problemi u zaštiti okoliša Osijeka - Zbornik ekoloških radova, Ministarstvo kulture i prosvjete i drugi, Tipografija, Đakovo, R. Hrvatska.

* (2000.): “Izvještaj o provedenom monitoringu oborina i otjecanja tijekom 1999. godine”, Zavod za hidrotehniku - Građevinski fakultet u Osijeku, R. Hrvatska.



Picture 4. Some of the monitoring problems