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The Preliminary Results of Smart Water Systems in Mitigation of Water Losses

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Abstract Innovative methods such as night monitoring, ground imaging devices, isolated zoning of water supply networks, water pressure management system integrated with SCADA system are effective methods or tools to mitigate water losses. Pressure and flows in pipelines could be measured using devices such as acoustic ground microphones, ultrasonic flowmeters, digital manometers and correlators and point trouble shooting of water flows could be managed. Furthermore, some troubles in water mains could be detected with pressure management system.

Kocaeli Province is located on Marmara Region of Turkey and one of the most industrialized cities. Izmit where is a county of Kocaeli Province is also one of the counties that have a lot of seepage losses. In the frame of Project of Mitigation of Water Losses in İzmit/Kocaeli, water losses (WL) would be abated by 20% using these tools or methods and, water savings of ten billion m^3 would be achieved. In this regard, 61 defects had been detected using by water pressure management system, 907 defects using by night monitoring and ground imaging devices, and these water losses had been prevented.

This paper aims to introduce the new methods and techniques in mitigating water losses. Moreover, the project results carried out in Izmit are discussed.

Keywords Innovative methods, water loss, mitigation, Kocaeli/Turkey

1. Introduction

The structural deterioration of water mains and their subsequent failure are complex processes, which are affected by many factors, both static (e.g., pipe material, size, age, type of soil) and dynamic (e.g., climate, cathodic protection, pressure zone changes). Condition assessment is critical to the management and maintenance of water transmission and distribution systems. The physical mechanisms that lead to pipe breakage are often very complex and not completely understood. The facts that most pipes are buried, and relatively little data are available about their breakage modes contribute to this incomplete knowledge [1-3].

Water is essential for human security and one of the engines of sustainable socio-economic development. At the same time, water is a precious resource which is gradually getting scarcer although it is a basic element for the eradication of poverty and hunger. More than half of the world population will be living with water shortage within 50 years because of a worldwide water crisis, according to a report issued by the United Nations Environment Program. In other words, it is highly unlikely that there is going to be enough water for everybody unless the necessary steps are taken at regional and global level. Population growth, industrialization, urbanization and rising affluence in the 20th Century resulted in a substantial increase in water consumption. While the world's population grew three fold, water use increased six fold during the same period. The demand on water resources will continue to increase during the next twenty-five years. The problem is further aggravated by the uneven water distribution on earth [4].

On the other hand climate change or variability are also truly global issues, and affect the whole water cycle as well as water is a vital and renewable resource to sustain life on the planet [5-6]. Possible scenarios indicate that summers would be longer/drier and warmer, winters would be shorter and wetter, extreme weather events/disasters such as drought and sudden/unexpected flooding, and seasonal droughts would be more frequent [7-8]. The impact of these changes would be felt across all parts of the water business. For example, reductions in river flows during summer periods are likely to reduce the amount of water available for public water supply. The natural recharge of aquifers from abstracted groundwater is likely to start later in the season, which may impact on water availability. Inundation of water treatment works by river water due to extreme weather events and resilience of the water supply system to multi-season droughts would be the most important problems to be faced in the near future [9].

Turkey is not a rich country in terms of existing water potential. On the contrary to the general perception, Turkey is neither a country rich in freshwater resources nor the richest country in the region in this respect [10-12].

With an increasing population, when considering the global climate change Turkey will have a more arid climate due in 2050, an amount of water per person per year in Turkey is expected to fall to 700 cubic meters. In other words, changing climate and growing population of Turkey by 2050 may be one of the water-poor countries [13]. Moreover, World Meteorological Organization (WMO), according to the survey which was conducted among 87 member countries result, it was determined that the 74 drought-affected countries, including Turkey also found. Again, from 87 countries in 59 (69%) are experiencing water scarcity problems. Asian continent to the west of the country, including Turkey and the Middle East and Africa, is one of the areas that are the most sensitive to increasing water scarcity problem [14].

Kocaeli Metropolitan City (KMC) is located on the Eastern Marmara Region, and one of the most industrialized cities of Turkey (Figure 1).

Figure 1: Location of Turkey (a) and Kocaeli Metropolitan City in Turkey

The great part of the domestic and industrial water needs of KMC was being supplied from Yuvacik Dam and Treatment Plant operated and maintained by private companies until 2014. The reservoir started impounding on 5th June 1998. The potable water and industrial water requirement was projected as 142 Mm^3/year and the regulation rate was 64.3%. As of January 2014, the operation of this dam and treatment plant which was being operated by Thames Water was transferred to Kocaeli Metropolitan Municipality. Due to water scarcity at the Yuvacik Reservoir and the other water resources, there could be a difficulty in raw water storage and supply of these resources which would result in water shortages on demand side. In fact, the water requirements of KMC can be supplied by Yuvacik Dam and Reservoir only. But this reservoir could not meet the water requirements of KMC in 2006 [15-17]. Furthermore, one year before water crisis in 2006, Kocaeli Drought Management Plan (KDMP) have been established with the participation and support of all the related authorities and parties on 31st May, 2005.Although KDMP was including all necessary subplots, programs and procedures to effective and practical dealing with the drought and the subsequent water conservation and the restrictions, it was not applied on time and completely. So, the public and industry could not find water sufficient to be used for utilities for ca. 30 days of December, 2006 [18]. After drought problem in 2006, KDMP was not revised and renewed. In spite of KDMP, Strategy for Combating Drought was prepared by Izmit Water Corp. and Kocaeli Metropolitan Municipality. But nobody has known about this strategy.

After water shortage and drought problem encountered in 2006, a water pipeline with 5 pumps, a long of 26 km approximately, was constructed from Lake Sapanca to Yuvacik Water Treatment Plant. So, the water needs of KMC was tried to be supplied for a short term. In July 2014, Namazgah Dam and a lot of deep wells were added to public supply system of KMC as the water resources. People living in KMC did not suffer from waterless in 2014 but all water and aquatic system were affected negatively in terms of quality and quantity.

According to ISU, the rate of water losses (WL) in KMC is 39 and 37 % respectively in 2014 and 2015 (Figure 2a) [19-20]. Indeed, this rate is much more than 37 % and approaches 50 % in consideration of total water amount used in KMC (Figure 2b.) Although accrued water amount by years has increased, it is not enough to mitigate WL.

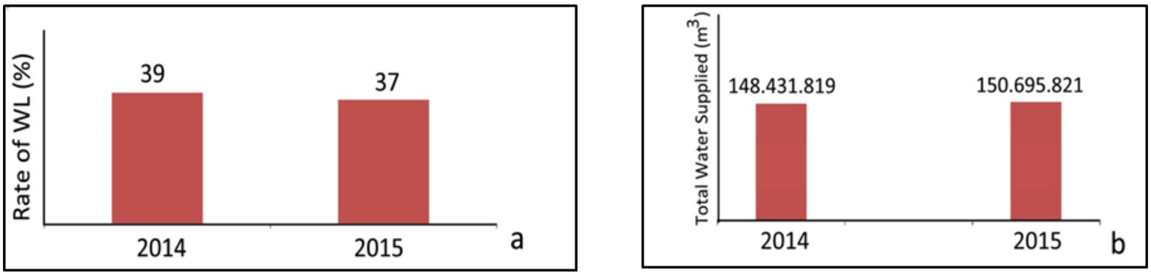

Figure 2: Rate of WL (a) and Total Water supply from Yuvacik Dam and Local Water Resources (b)

Kocaeli has 12 districts and of them, Izmit (central district) is one of the districts that have water loss and defects by far the most [21].

This study aims to introduce the new methods and techniques in mitigating water losses in Izmit District and the preliminary results of project carried out in Izmit are discussed.

2. Water Loss Mitigation Projectin Izmit District/KMC-Turkey

This project is developed to mitigate water loss in Izmit District of KMC-Turkey where water demand, population density and water losses are getting increased year by year. The project is carried out in 52 districts of Izmit and coverage area is 58 km^2 (Figure 3). In the frame of Project water losses would be abated by 20% using these tools or methods (innovational tools and methods) and water savings of ten billion m^3 would be achieved.

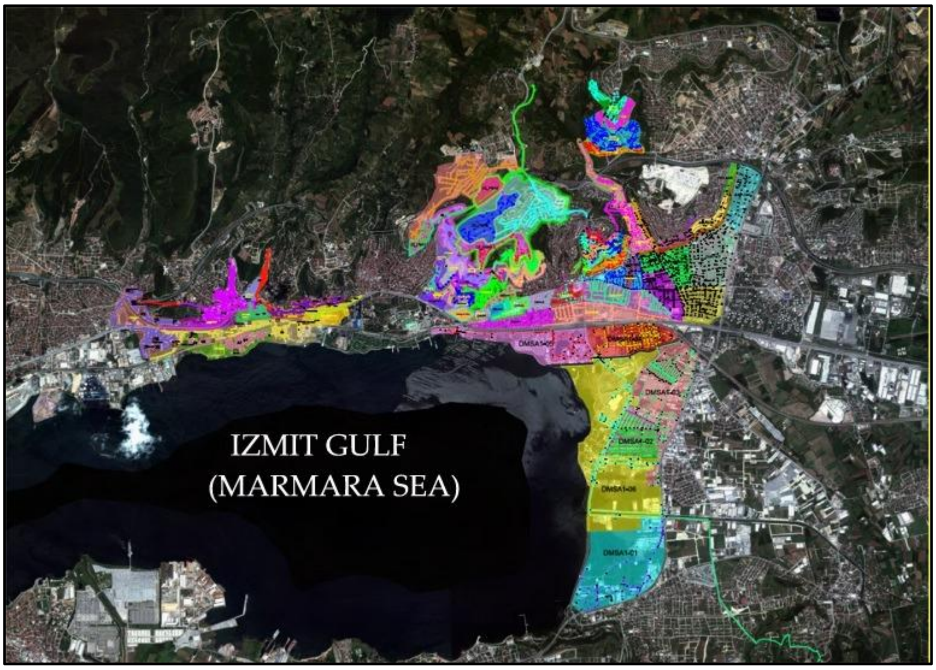

Figure 3: Coverage Area of Water Loss Mitigation Project in Izmit/KMC

2.1. Tools and methods used in the project

Innovative methods such as night monitoring, ground imaging devices, isolated zoning of water supply networks, water pressure management system integrated with SCADA system are effective methods or tools to mitigate water losses. Pressure and flows in pipelines could be measured using devices such as acoustic ground microphones, ultrasonic flowmeters, digital manometers and correlators and point trouble shooting of water flows could be managed. Furthermore, some troubles in water mains could be detected with pressure management system.

In the project, 32 DMA (District Meters Area) and 15 PMA (Pressure Meters Area) were formed as the network. Inlet/outlet Pressure and flow can measure in DMAs while PMAs are working under constant pressure. DMAs involve vacuum lifter, manometer, smart valves, flow meter and filters (Figure 4).

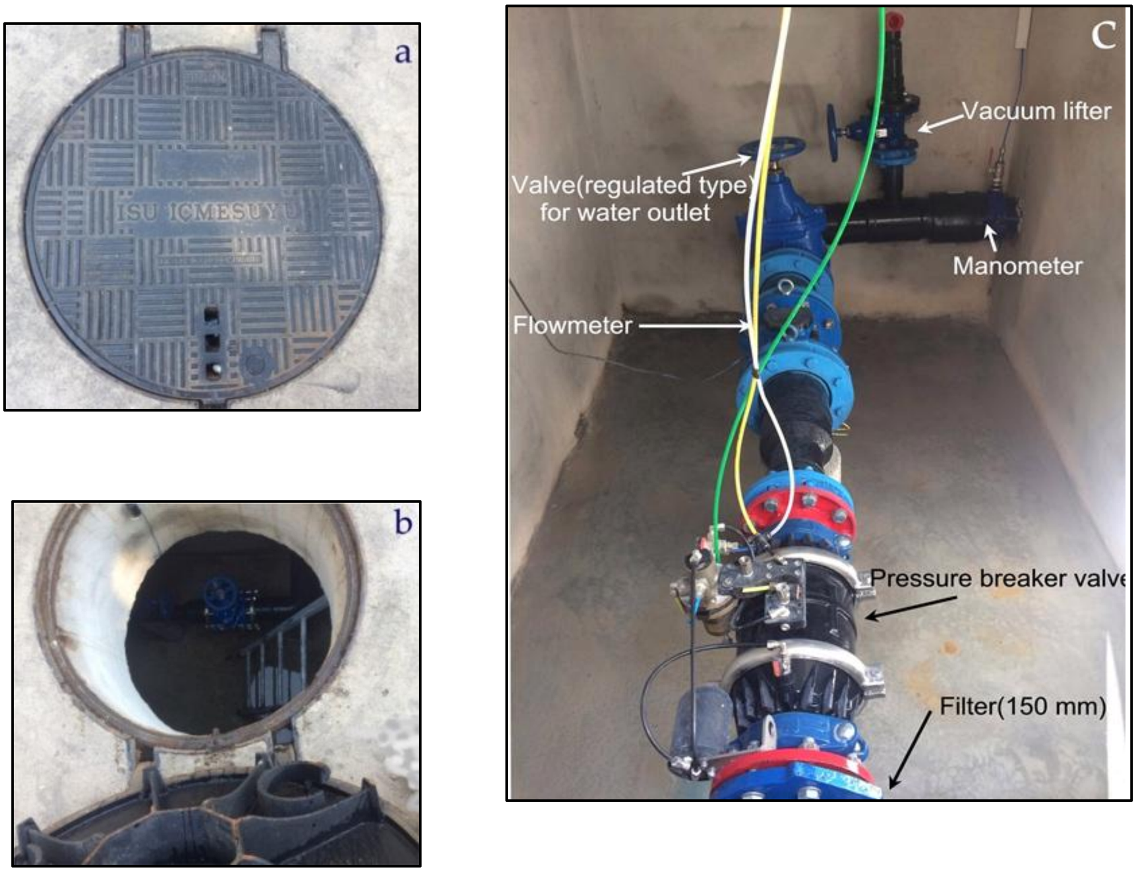

Figure 4: External view (a and b) and internal view(c) of a DMA

DMAs are working as to flows. Required arrangement can make by measuring pressure (inlet and outlet) and flow instantly or periodically. Pressure and flow changes can monitor via curves from computer screen in control room (Figure 5). Data can collect measuring night and daytime, and mean flows. These data are being compared with IWA standards and deviations are being determined.

In due course of any defect, system is giving the warning signal through internet and defect is being determined and interfered (Figure 6).

In Critical Points, pressure measurements are being made continuously. Outlet pressure can change as to elevation difference. The deviations from normal data in Critical Points of PMA are being registered and these deviations in pressure are giving a warning. So, a presence of problems is revealing in the system (Figure 7a and 7b). Moreover, water pipeline can be controlled using pressure breaker valve.

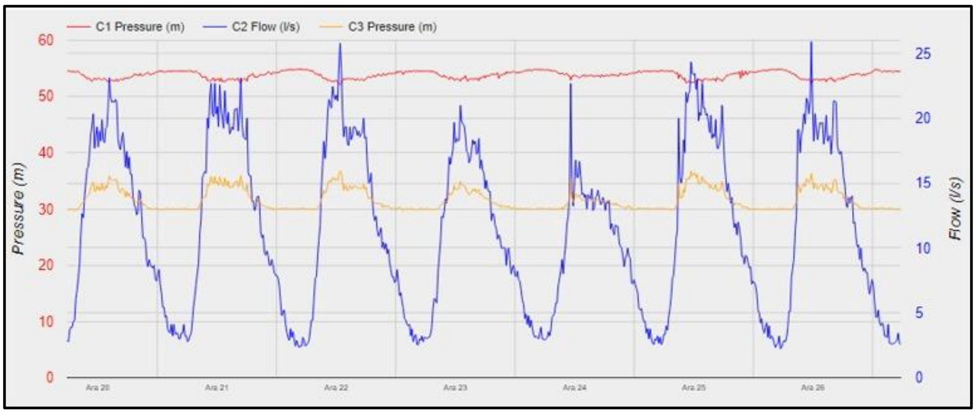

Figure 5: Inlet/Outlet Pressure and Flow Curves on Computer Screen among 20-26 December 2017

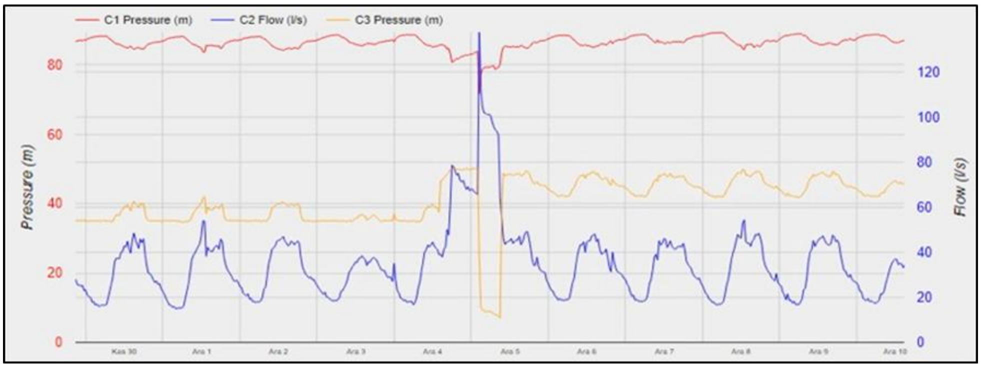

Figure 6: Extreme Flow Changes in Due Course of a Defect among 4-6 December 2017

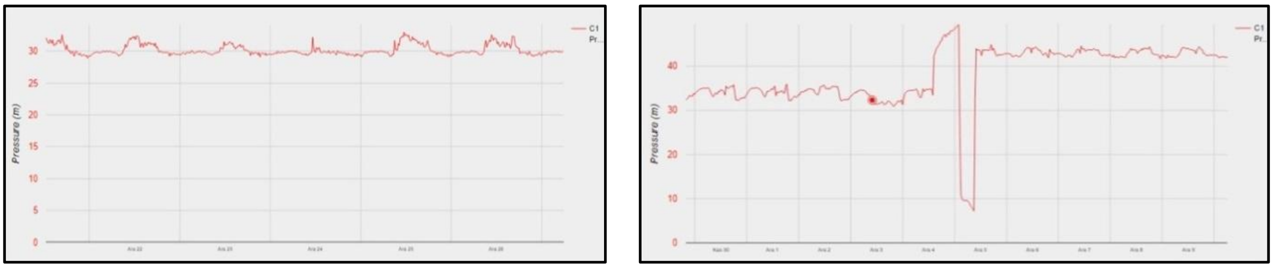

Figure 7: Normal pressure (a) and deviations from normal pressure (b) in CPs during December 2017

Many utilities use pump control as a method of controlling system pressure. Pumps will be activated or de-activated depending upon system demand. This method is effective if the reduced level of pumping (usually at night) can still maintain reservoir levels. The exact place of defects can determine using permalog (Figure 8a).

Permalog enables water suppliers to quickly and efficiently locate leaks in the water network. Loggers are deployed in areas of the distribution system to provide continuous monitoring of leakage. Easily installed on pipe fittings, they are retained in place by a strong magnet and are powered by low cost replaceable batteries. As soon as a potential leak is detected, the Permalog unit enters an alarm state and transmits a radio signal to indicate a "**LEAK**" condition. In the project, 20 Permalogs are being used for now. To understand how acoustic water leak detection works, one must understand the interplay of following four factors: the different types of sounds water leaks make, the various factors affecting the sounds, how the sounds travel down pipes, and how the sounds travel through the soil. Defects or leakages in the locations where permalogs were not used are being trialed to be found by means of GPR (Figure 8b), GPS (Figure 8c) and Acoustic Sonar Microphone (XMIC Trademark)(Figure 8d).

Figure 8: Permalog (a), GPR (b), GPS (c) and Acoustic Sonar Microphone (d)

The underground mapping of water network can realize using GPR (Ground Penetrating Radar-IDS GeoRadar), GPS (Global Positioning System) and Acoustic Sonar Microphone. Ground penetrating radar inspection is a non-destructive geophysical method that produces a continuous cross-sectional profile or record of subsurface features. Methods like this could be used to locate leaks in water pipes by detecting either underground void created by leaking water as it circulates near the pipe or by detecting anomalies in the pipe depth as measured by radar. Underground utility locaters (GPRs) are growing increasingly complex. In addition to metallic utilities, a new generation of non-metallic utilities such as fiber optic cables and PVC piping as well as increased density of buried assets has created a more challenging underground locating situation. GPS (CORS SATLAB SL600 Model) is built on a LINUX based operating system which controls all hardware and communications for an error free and easy to support solution. Its voice prompts will advise you of any issues together with a solution.

Acoustic Sonar Microphone detects and amplifies the noise created by leaks in pressurized pipes, and the leak position can be verified by surface sounding for ground surveying or prior to any excavation and repair being carried out. This speeds up repair of the leak, reduces repair costs and ensures that disruption to the water supply is minimized.

Using these innovational methods and equipment WL was decreased 38% at the end of 2016 and 33% at the end of 2017. At the end of 2018, WL has been targeted to decrease 25% and water savings will be 10 Mm^3 (Figure 9) [22].

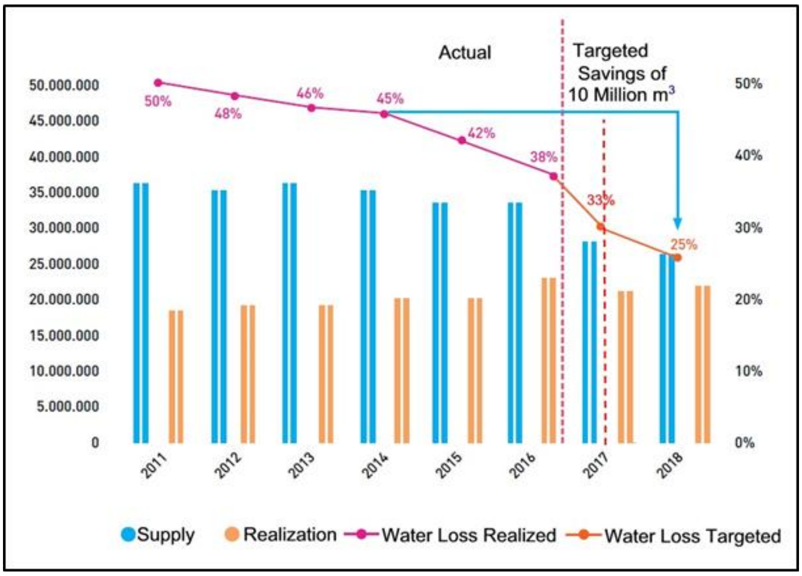

Figure 9: Actual and Realized WL in Project Area

3. Data Information and Storage

In the area of water distribution network management advanced communication systems and software applications are playing an important role in being able to take informed decisions timely and accurately. The current trend is to apply solutions which combine information technology and telecommunication network using www or GSM networks for the transfer of data which is obtained form site devices, such as water meters, pressure sensors and so on. Careful consideration and examination of the available technologies must be given in order to adopt an appropriate system with low capital expenditure as well as low operational and maintenance cost.

A typical communication system for the storage and transfer of valuable information is shown diagrammatically in Figure 10 providing all the necessary information for the efficient and effective management of a water supply system [23].

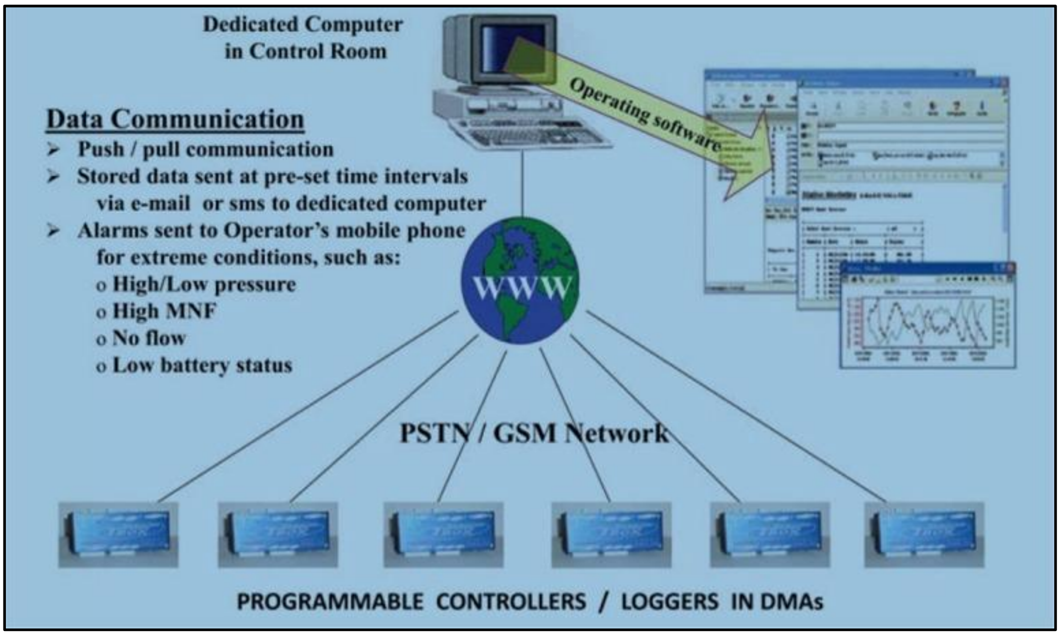

Figure 10: A typical setup for transfer of a data acquired and stored on critical site locations

4. Discussion and Conclusion

It is recognized that losses of water supply network is a problem worldwide. The problem in Turkey is as great as countries with older systems in developing or underdeveloped countries. Water losses in both water systems and pipelines can have significant ecological and design effects, with overdesign of systems and the associated pipework being a major cost factor in providing a service to customers.

This is compounded by recent changes to the way water authorities operate, where capital expenditure needs to be justified as being cost effective before any replacement or maintenance of pipes occurs.

To solve leakage in both sewer and water network systems, sophisticated leak detection techniques are required. The best method of leakage detection and control is very dependent on the type of system and customer base in the utility. Whilst new systems may appear, the most likely developments will be in the combining of current systems. The most significant factor requiring water authorities to undertake such exercises, however, will be the public perception of water losses. This is already happening in Turkey where WL is becoming of environmental concern to the public. The focus of the media up to now has largely been on water pipe leakage, but the future focus will be on sewers.

A number of procedures can be undertaken to reduce leakage in both sewers and water supply systems. In sewers, the only existing technology is rehabilitation or replacement. For water network pipelines, either rehabilitation can be undertaken or pressure management techniques instigated. Pressure management can be a very cost-effective means of reducing losses or controlling demand, for many utilities, with a wide diversity of conditions. As with any potential investment, in loss control or demand management it is important to carefully model or calculate the effects and benefits of the control prior to implementation to ensure ongoing system requirements while cutting out unnecessary losses and system inefficiencies.

The choice of which rehabilitation technique or whether rehabilitation needs to be undertaken at all is currently difficult as little information is available to aid selection of the appropriate technology. Asset management systems need to be developed to allow technology selection, taking into account lifecycle costing methodologies as well as externalities, such as customer disruption and health risks.

The aim of the project is to mitigate the water loss up to 20 %. Within a year, water losses were decreased 33% using these methods and tools. After the Marmara Earthquake happened in 1999, infrastructural imperfections in KMC cause troubles in fixing of water network. Water network was damaged severely because of earthquake. Therefore, on the onset of the project, a reduction of 15-20 % nearly water losses and can be regarded as a step of success. As of the end of 2017, deficits that are more than thousand have been determined and required measures have been taken. But, the software of domestic water management system should be realized to form completeness of the data acquired at the end of the project. Furthermore, information flow should be integrated with SCADA system.

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