International Research Journal of Biochemistry and Bioinformatics (ISSN-2250-9941) Vol. 3(2) pp. 44-51, February, 2013
Available online http://www.interesjournals.org/IRJBB

Full length Research Paper

Long-lasting management of the supply of drinkable water: reduction of the leaks; application to the primary network of Bonaberi in Cameroon

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Accepted 06 March, 2012

In time, the pipes of distribution lose their water proofness. Water leaks become important and provoke so many damages (flood of spaces, disturbance of road traffic, and break of distribution of drinking water). In a local area of distribution of water, the recurring problems are generally owed to the leaks; the curative maintenance becomes ineffective and economically not viable. The setting-up of a preventive maintenance allows reducing the leaks at the level of the channelling through real-time interventions. In this article, we are interested in the implemented of a method of real-time detection of the leaks on a drinkable water distribution system. It drives to the long-lasting management of water reserves. It is based on the following-up of the information of the sensors giving the parameters of drainage (pressure, debit) the data recorded in the various control points is permanently compared with the reference data (standard). A difference between these data indicates an anormality and informs about the state of the pipe. The data recorded with the location of the sensors establish the Geographical Information system (SIG). Besides its classic functions of acquisition, storage, an algorithm of treatment is integrated into the SIG. it allows to diagnose and to localize the presence of water leaks on the network. The model coupling the parameters standards with the real data of the network allowing detecting the leaks is applied to the water distribution system of the region of Bonabéri to Douala in Cameroon.

Keywords: leaks, maintenance, water distribution system, SIG (Geographical Information system), standard.

INTRODUCTION

The Access to the drinking water is a stake mattering in the world. If a man can cross days without electricity and without food, it is on the other hand impossible to cross more than a day without drinking. The volume of drinking water represents only 1/3 of the total volume of water in the world (Banque, 2004). By 2025, 300 millions of African risk to live in an environment where the water will be rare with a population which risks to exceed the cape of the billion. At present, 25 % of the urban population in Africa is badly furnished with water. (Morel, 1990).

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To supply with drinking water and a purification adequate to all the households in Africa sub-Saharan, will be needed 47 billion dollars (Narendra, 2002). By place, the situation is a criticism and the threat on the public health, the food safety, the follow-up of the human beings and the environment is immediate (Cameroun tribune, 2004). A study led on the network of Douala in 2002 has allow us to see that the demand in water in the region (Douala) believes proportionally in the leaks (Mbemmo, 2002). The state of degradation of the installations due to the lack of regular maintenance is worrisome. Where from the idea to assure a real-time maintenance of the installation (Baron1, 1992) and so, to diagnose the leaks. The purpose is to reduce considerably the losses to satisfy

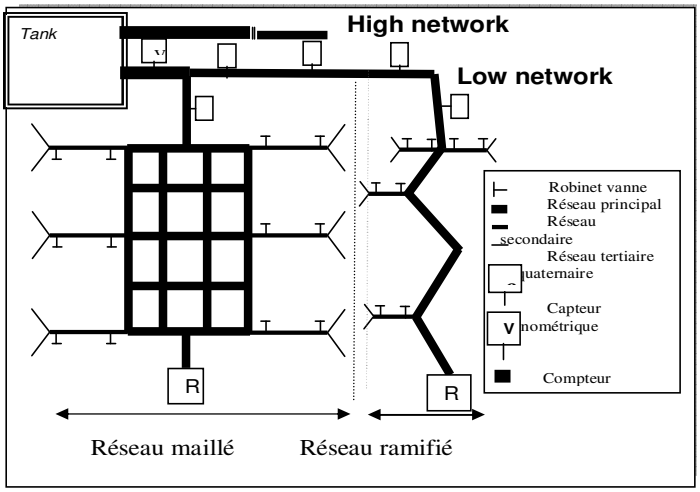

Figure 1. Structure of the water distribution system to Douala

demands in wait and assure a regularity of distribution of water.

Having describe the structure of the network to be studied, the techniques of real-time diagnosis are proposed in the paragraph 3. The algorithm allowing coupling the parameters standards with the real data of functioning is presented in the paragraph 4. This algorithm allows activating the conditional preventive maintenance of the network. The developed method is applied to the network of water of Bonabéri (Douala - Cameroon). The experimental results will be presented to the paragraph 5. A conclusion with perspectives of extension will end this article.

Structure of the network studies

Presentation

The city of Douala is fed by two pipe of 800mm of diameter got in the treatment station of Japoma. The structure of the water distribution system is represented by the figure 1.

The network is constituted by two pipe: One constitute the low network, sprays the low part of the city and the other constitutes the high network spray the high part of the city. Bonabéri is a low region of Douala. The network of water which sprays the zone is pulled from the low network by a pipe of 350mm of diameter until the crossing of the bridge. Then, until the exit of the bridge there is a pipe of 300mm, followed by a resumption of 350mm by diameter which divides in two branches at the level of "the new road", the variation of diameter of the main pipe goes from 350 to 300 mm, while on "the former road" this variation goes from 200 to 800 mm

The constituents of the network of Bonabéri are similar to the classic urban networks [Shuo, 1995). (Figure 1).

- Channelling in cast iron and pvc
- Faucets and gates
- monographs recorders
- Volumetric meters
- Castles and reservoirs of waters
- Fire hydrants
- Suppressors

Problem

The water distribution system in several African cities dates colonial period (Shuo, 1995).

The arisen works of extensions did not take into account certain problems generated by these modifications. We have.

- The sizing of the structures
- The follow-up of equipments and the detection of the leaks
- The wear and the ageing of the pipes
- The adaptation of the techniques of maintenance to the dimensions of the Network

Where the necessity of setting up an initiative. It drives to the resolution of the sub-quoted problems. The proposed initiative is based on the analysis of real registered data on-site (apprenticeship). In this context, the registered data must be treated by a management system consisted of the following four functions.

- The function apprenticeship
- The function acquisition
- The function treatment

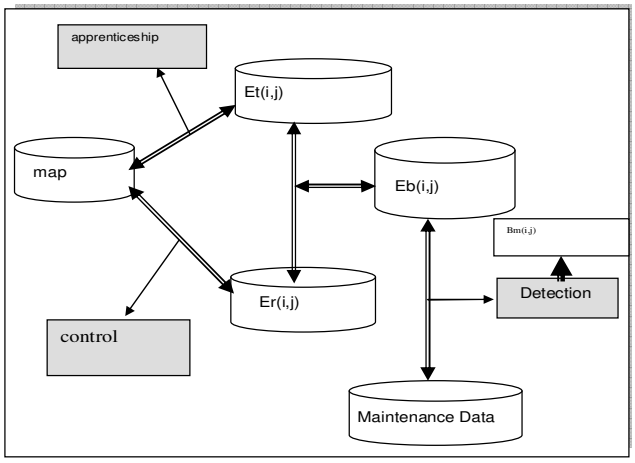

Figure 2. General Architecture of management of the network

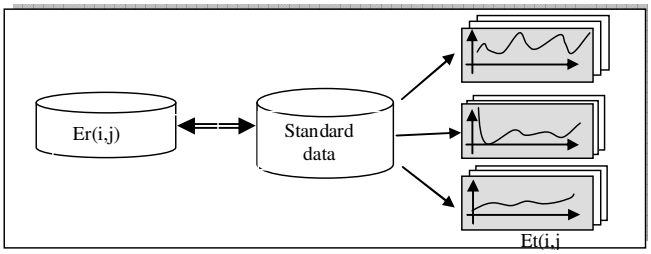

Figure 3. Apprenticeship of the network

- The function detection of the leaks and Maintenance.

Organization of the geographical information system

The detection of the leaks on a drinkable water distribution system are based on the follow-up of the information of the sensors looking the parameters of drainage (figure 2). These parameters are essentially the debit and the pressure. Sensibly positioned control points allow following the evolution of these parameters. The data registered in the various control points are permanently compared with the reference data beforehand established. It is what corresponds to the data standards obtained in phase of apprenticeship.

A difference between its data indicates an anormality (leak) and informs about the action of maintenance to be realized. The data registered with the location of the sensors constitute the Geographical Information system (SIG). The SIG is a system which integrates not only the classic functions of acquisition but also, the storage and the algorithm of treatment. The exploitation of the data integrated into the SIG so allows, to diagnose and to localize the presence of water leaks on the network.

The objective is to know and to realize on a graph the behaviour of the water distribution system according to the movements of the population and the variation of season. To do it we inspire us on the principle of the networks of neurones (Baron1, 1992). Those are observed and register the movements of the network during a long period. All the normal variations will constitute a base of reference called «given standards ".

The data standards will afterward be compared with the real parameters to diagnose the state of the network and activate the operations of maintenance. So, four phases are necessary:

- Phase 1 apprenticeship: identification of the network
- Phase 2 acquisition: backs up data
- Phase 3 treatment: diagnosis of the network
- Phase 4 decision: detection and maintenance of the network

Apprenticeship

The apprenticeship of the network of drinking water during a period long and suited (taking into account seasonal swings, movements of the population) allows to know the behaviour of the network and the beach of its parameters of functioning (pressure P, debit Q, coordinated geographical R (i, j). This knowledge allows to create a database standards as shows it the figure 3.

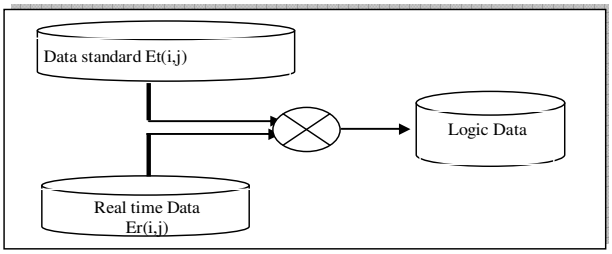

Figure 4. acquisition of real-time data

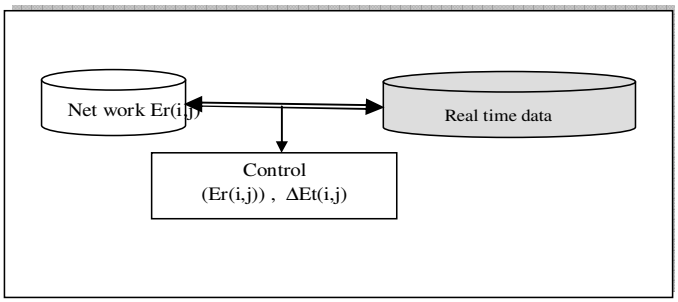

Figure 5. detection and diagnosis of the network

Reference curves in debit and pressure are so obtained in every control point of the network R (i, j). The parameters standards are noted Ei (i, j) where i corresponds to the geographical position and j the time of recording.

Acquisition of the data

During the normal functioning of the network, the sensors register the pressures and the debit of drainage the hour per hour. The data so collected are stored in a real database. It is the phase of acquisition that is schematized on the figure 4. The surveillance of the network allows detecting in most rather the abrupt variations of debit. A tolerance is associated with every knot of the network. The value is calculated according to the place of the sensor (type of primary or secondary network) and of the number of connections to the tertiary network and the return on the network.

Diagnosis of the network

During the functioning, the real parameters of the network are real time found and compared with the database standards. The result of comparison is registered in a database which we shall name “logical” data as the figure 5 shows it.

The comparison is made by the algorithm of coupling. This algorithm allows to compare the on-site obtained real data with the data standards obtained by apprenticeship of the network. It indicates the failures on the network and shows the conditions of maintenance of the zone with problem.

Detection and maintenance

The nature of the data informs about the behaviour of the network. What gives information onto the nature and the scale of the flights (leaks). The comparison of the logical data with the database of maintenance allows starting the operations. A base of looking maintenance, the indications of the network, the profile of the technicians, the indispensable equipment, the index forms of works and maintenance are defines for every channelling and in a base Bm. In case of signal starting by the comparison of the parameters of drainage and real, the base is updated for the action of maintenance.

Inspection

Once the diagnosed leak, the algorithm shows on the map the failing points. It allows the technicians to go down on the ground and for localizing the leak.

Maintenance

The base of maintenance is constituted: of the profile of

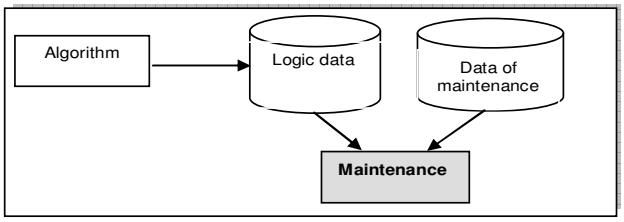

Figure 6. Maintenance of the network

Table 1. Volumes of water in Bonaberi

Mois	Volume produit en m^3	Volume facturé m^3	Rendement	Moyenne
juin	176100	115281	0,65	
juillet	199400	115381	0,58	61%
Août	192600	116500	0,60	

Table 2. Manographe on the network

Emplacement des points de contrôle	Indexation (i)
Avant le pont	i=1
Entrée du pont	i=2
BONABERI château	i=3
BONASAMA Gendarmerie	i=4

the technicians, the description of the equipment of maintenance and sticking, index forms of maintenance, the description of the channelling. Under the coordination of a person in charge maintenance, every on-site carried out technician his task seen to seal the leak.

Application to the network of bonaberi

The distribution network is marked out by several sensors who collect the parameters of drainage. it presents a weak return (61 %). What shows the necessity of implanting a initiative of diagnosis and maintenance of the leaks).

The return on the network is obtained by making the report of he volume produced a month on that consumed. The sum of the daily volumes read on the meter placed in the entrance of the zone allows us to obtain the monthly volume. These volumes are directly obtained in the service of exploitation of the network.

The invoicing of the monthly volumes consumed by subscriber is insured by the sales department of the national company (society) of distribution of drinking water. To realize its work, the sales department divided Bonaberi into zone and zones in island. Elevators go in islands to take the volumes consumed by subscriber. What allows obtaining the volumes charged by zone. The sum of the volumes charged by zone gives the charged monthly volume.

Repository data of etallonages

Manographes (or sensors) placed on the network (Table 2) give the pressures the hour per hour to the considered points. For this application, we limited ourselves to four tender spots of the network. The indexation is given by the Table 2. We shall have in entrance of our algorithm a number of sensor m=4.

Standars datas

Four control points of the network are fixed and their positions on the map allow to localize them. For the follow-up of the state of the network, it is necessary to follow the pressures and the debit (flow) Shuo, 1995). For this application, the current data allow to follow only the parameters of pressures.

Pressures standars

From the statements of the monograph and the analysis

Table 3. Standard parameter average

h / i	1	2	3	4	5	6	7	8	9	10	11	12
1	304	308	310	312	309	302	268	259	249	250	251	255
2	163	169	170	171	169	162	143	132	120	116	115	118
3	102	105	108	107	100	77	72	67	62	61	63	62
4	70	71	73	74	72	55	44	39	36	36	36	38

13	14	15	16	17	18	19	20	21	22	23	24
304	304	304	304	304	304	304	304	304	304	293	300
122	128	128	128	130	134	134	137	145	147	152	158
64	66	68	70	70	71	71	80	83	83	89	96
40	42	41	41	43	44	46	45	70	52	54	64

Table 4. Matrix of variations of standard data

h / i	1	2	3	4	5	6	7	8	9	10	11	12
1	45	40	40	35	50	60	50	40	50	50	50	40
2	12	10	5	5	15	30	15	15	10	10	15	12
3	27	31	35	25	25	25	25	15	15	30	25	15
4	42	40	39	30	25	30	35	25	15	15	20	20

13	14	15	16	17	18	19	20	21	22	23	24
45	45	45	45	45	45	45	45	45	45	50	45
7	7	10	10	7	5	7	5	7	10	10	10
20	25	20	30	15	20	20	30	30	20	25	23
20	20	20	25	30	30	35	35	35	50	40	50

on Excel, we have the pressures standard before the bridge in the point i=1. In the same way, we treated the points i=2 in i=4 to obtain the matrix. Table3 and 4

The curve of the figure 7 shows that the basic period's pressures in water is situated between 5 am and 12 am. That corresponds at the hours of strong consumption. Apprenticeship, acquisition, diagnosis and detection maintenance

Chosen point: Bonasama gendarmerie

On the curve figure 8, the data standards and real are stacked. A case of leak was noticed .

Bonasama corresponds to the point of sensor i=4 on the algorithm. On the Table 4, are indicated the constituents of the base standard, of the real base and those of the logical base associated with the studied case.

The beginning of the leak is 2 pm, time of detection. The action of maintenance started at 3 pm and the situation became again normal at 5 pm. This studied case accentuates a initiative highlighting the phases of apprenticeship, real acquisition of the data at time, the detection, followed by the maintenance of the network. The associated data of maintenance are: the display of the list of the staff capable of intervening on the failing network, the list of the material of maintenance and the index forms of works.

ANALYZE RESULTS

Of the taking made on the network of Bonaberi, we noticed that the average return is 61 %. What supposes a loss about 40 % a month. For a zone in lack of waters these losses are enormous and explain on one hand the necessity of this project.

From the standard matrix it emerges that the periods of strong water consumption to Bonabéri are situated

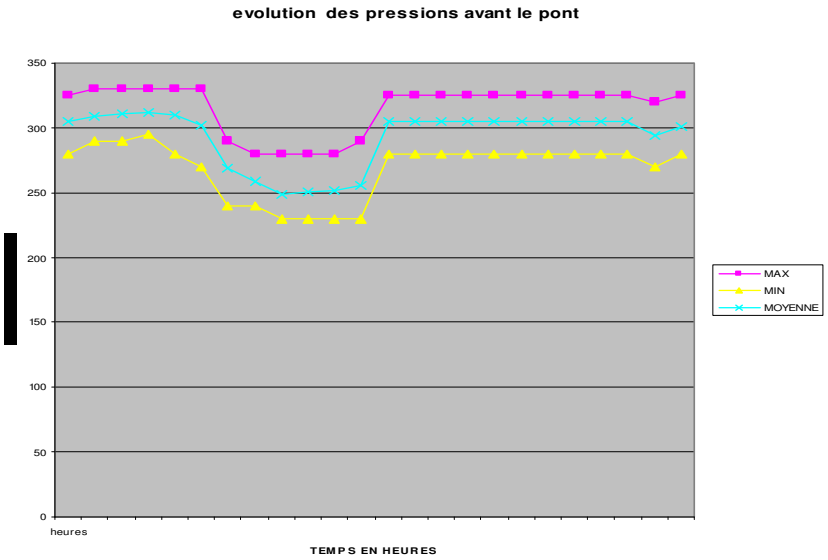

Figure7. Curve of apprenticeship on the point site before the bridge

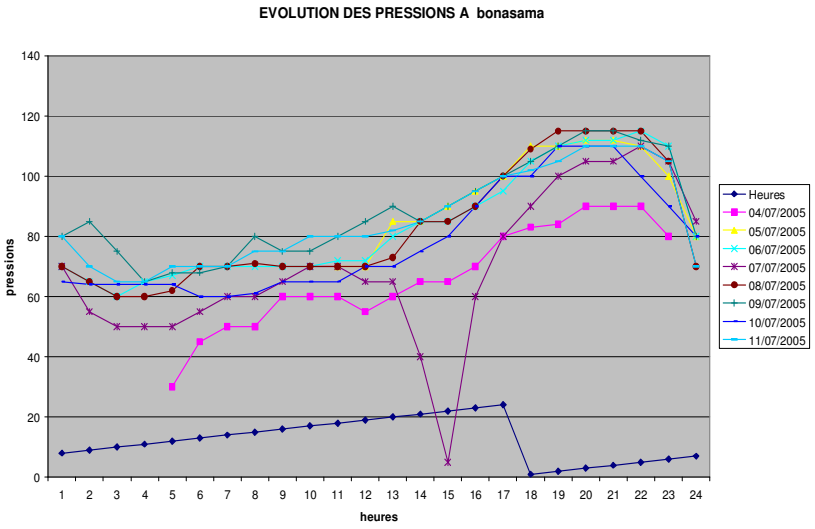

Figure 8. case study of a detection of leak

Table 5. standard Matrix, real time pressures and logics

	1	2	3	4	5	6	7	8	9	10	11	12
Et4	70	71	73	74	72	55	44	39	36	36	36	38
Er4	71	70	69	69	68	70	70	71	71	72	73	50
Eb4	1	1	1	1	1	1	1	1	1	1	1	1

13	14	15	16	17	18	19	20	21	22	23	24
40	42	41	41	43	44	46	45	70	52	54	64
35	19	2	19	35	70	80	85	86	88	90	95
1	0	0	0	0	1	1	1	1	1	1	1

between 6 and 13 o'clock. Thanks to the model, The losses are crossed(spent) by 40 % in 30%de the global production of water in the region. But the number of sensor remains reduced. The base of three months useful for the setting-up(presence) of the model is weak and will have to hold in account the variations of season and the movements of the population to improve this return. An analysis of the ageing of the channelling according to time will allow a systematic preventive maintenance of the water distribution system.

CONCLUSION

In the term of this work, it emerges that the detection of the real-time leaks contributes to the reduction of the losses on the distribution network. What allows a long-lasting drinkable management of water resources participates in actions of environmental protection and contributes widely to the increase of access to the drinking water. The parameters of drainage of the fluid are real time taken in and the treatment postponed from 24 hours.

For a real-time treatment, the cost of the operation is raised and we attend a material redundancy. Besides the collection and besides the data processing one employment of the receiving broadcasting sensors and the technicians specialized for the phase maintenance. The advantage of this method is to allow an optimal reduction of the volume of water lost during the break-in.

A recorded treatment admits an investment reduced to the work of conception to the collection and to the data processing. No supplementary component is added to the network except some recorders or sensors considered useful and placed in the points of collection of the parameters flow. For the special case of Bonabéri to Douala Cameroun, whose losses are situated about 40 % of the production, such an application admits a time of return almost nobody. In every case, the apprenticeship of the network, the low connections of data, SIG and mapping is used to implant and insure a detection of the leaks leading to a preventive maintenance. The works turn at present to the TV detection

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