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ANALYSIS AND EVALUATION OF THE POTABLE WATER NETWORK AND WATER QUALITY IN AL-DIWANIYA CITY

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ABSTRACT: In this research, the reality of the potabale water services in AL-Diwaniya City was studied, it in two essential lines:

First, the analysis of water distribution in the city trunk network, by using the program (pipe++) version 1998 to get the quantities and the directions of discharges water. Also it uses head pressure in some related network nodes. Measurements were made, infield, from each region to estimate head in each trunk in order to specify the regions that suffer from shortage in water.

Second, the work to evaluates the suitability of raw and supply water. Samples of potable water were taken from the plant taps and from taps in each region on July 2003. Water born diseases in drinking water were specified during 2002

Statistical analysis was applied to the available data, including the AN OVA test, correlation test, and the results were as follows: -

Raw water and drinking water considered as suitable for human use according to the Iraq and International drinking water standards. Although exceeding the acceptable border for each of (turbidity, hardness, sulphate, Calcium) but all of them are below allowable limit.

- Good significant relation between the percentage of polluted tap water and typhoid during the year of study.
- Residual chlorine for each regions (2.5-0.75) mg/L.

Keywords: Analysis, water, network.

1- INTRODUCTION :

The objective of the distribution system is to supply water to each and every house, industrial plants and public places. Each house must be supplied with sufficient quantity of water at the desired pressure. [lencastre 1987].

Nilsen,(1989) : studied different methods of pipe networks for analysis. He formulated the flow equations in terms of both pipes discharge and energy heads and the problem reformulated in terms of vectors and matrices. To solve the problem, three different methods were used; the linear theory, Newton-Raphson and the general-purpose optimization algorithm to the problem. The method shows that the formulating flow resistance in terms of energy heads has two great advantages, the reduced system, and easy to implement a computer program that solves the system. The disadvantages are it is difficult to get a good starting vector and the convergence may be very slow. Formulating the flow resistance in terms of pipe discharge has advantage of reducing the number of primary unknowns (m-n) to (n/2), where (n) is the number of primary unknowns, and has one disadvantage of the need for computing a basis for the complete solution to the continuity equations. Demonstrated that an

efficient method for analyzing pipe networks consists in solving the generalized loop equations by means of the Newton-Raphson method

combined with the linear theory method as a simple and robust starting procedure.

Abdul-Jabar (1997) : uses a modified finite element method for the solution of pipe networks. The method does not need any initial assumption. Starting point depends upon a selected range of Reynolds's number between "350000 - 550000" according to the size of the system. Any components can be presented and different pipe properties may be introduced.

Al-Samawi (2000) : offers an approach that is the method of sections in the analysis of water distribution network, program is prepared and written in "Quick Basic" language in order to carry out the analysis processes, and compared it with the Hardy Cross method. The results of that study indicated that an agreement improve between the values of the pipe diameters as obtained by the method of sections with those obtained by the Hardy Cross method as the number of feeding sources into the network increases.
It was found that the method of sections produces value of pipe diameters lower than those obtained by Hardy cross method.
Meller and waste (1968) : proves that the use of alum (aluminum sulfate) as a clotting material in the projects of purification for drinking water leads to the increasing of concentration aluminum in the treated water of such projects while the concentration of it in the raw water reaches the rate of (40-50) % and the rate of the removing of aluminum for the two stages of settlement and filtration is (85%) and (95%) respectively when the circumstances of operation are ideal and the amount of aluminum that is left in the treated water is transported through the system of distribution .

Abu Hamdeh's (2000) : study is aimed to find out the suitability of Tigris water quality to be used as a source for drinking water and to evaluate the treated water of the running conventional water treatment plants in Baghdad City.He shows that the Tigris water was classified as a good and suitable source for drinking water in Al- Karkh and 9 Nessan intakes, and it was classified as a polluted and heavy polluted source in other intakes.
The study shows that the drinking water being supplied by running water treatment plants in Baghdad city during the study period is considered as suitable for human use according to the Iraqi and the international drinking water standards, because of use intensive disinfecting process in water treatment plants.

Alwan (2001) : samples of drinking water were taken from all water supply treatment plants, which are seven in number, in addition to other samples of tap water from the nine regions in the city of Baghdad.The study shows that the bad quality of drinking water can be attributed to two sources, the first, some of water supply treatment plants in their performance has been lowered because of the ongoing blockade imposed on Iraq. For examples, bad qualities of alum have been used, and there is a shortage in chlorine, the maintenance of various stages of water treatment has been ignored. The second source of the problem deals with treated water pipe networks as most of these are very old and need replacement.

1.1 objective of research

The research is trying to achieve evaluation of the main pipe network and to estimate shortage in it and evaluate supply of water that is supplied from the Al-Diwaniya water treatment plants

2. DISTRIBUTION SYSTEMS:

The main purpose of the distribution systems is to develop adequate water pressure at various points i.e., at the consumer's tap and the choice of the distribution and its elevation with respect to the location of the water treatment plants. The distribution systems may be classified into three categories [Fair et al ,1971 and Singh 1974]: -

1. Gravity system.
2. Pumping system without storage.
3. Dual system with storage.

3. DIFFERENT LAYOUTS FOR DISTRIBUTION SYSTEM:

There are four methods of laying distribution pipes in locality or colony (Singh 1974 and Duggal 1997): -

1. Dead- end or tree shaped system.
2. Grid system.
3. Circular or ring system.
4. Radial system.

4. FUNDAMENTAL PHYSICAL LAWS FUN:

The fundamental physical laws governing the hydraulic analysis of networks can be summarized as follow [lencastre 1987]: -

4.1 Mass conservation Law:

The algebraic sum of the flow rates in the pipes meeting at adjunction, together with any external flow, is zero

i = NP(j)

$$\sum \quad qij - Qj = 0 \qquad j = 1,Nj \qquad ....(1)$$

where: -

q_{ij} : the flow rate in pipes i at junction j, (L^3/T)

NP (j): the number of pipes meet at junction j.

Qj : the external flow rate (commonly called consumption or demand) at junction j, (L^3/T).

Nj : the total number of junction in the network

4.2 Energy Conservation Law

The algebraic sum of the head losses in pipes forming a loop must be zero, thus,

$\sum h_{fi} = 0$ For all loops(c) …. (2)

Where: - h_{fi} : head loss in pipe (i)contained in loop (c),(L).

4.3 Head Loss - Flow Rate Relationship

A relationship between the flow rate and head loss in any pipe or element is maintained through the analysis by an exponential formula of the form: -

$$h_{fi} = Kiq_i^{n*} \qquad ….(3)$$

where: -

h_{fi} : Head loss in pipe i, (L)

Ki : a pipe line constant which is normally a function of pipe Length, diameter and type of pipe material.

q_i : flow rate in pipe i, (L^3/T).

n * : An empirical head loss exponent usually ranging between 1.8 And 2 (lencastre ,1987).

5. NETWORK DESCRIPTION

The office of water in AL-Diwaniya at the beginning of the 80th made a plan for producing water and increasing its production. The plan consists of restricting periods for achieving and expanding some projects in addition to the establishment of new network including trunks, reservoirs for storing water to balance the needed for peak demand, and pump stations for pumping puiposes. A great percentage of this plan was achieved, for instance the great part of the main pipes in the pass of the network were replaced with new main pipes .One of the stage of this plan was to implement (AL-Mowahad water treatment plant). Fig (2) shows the layout of pipe network in AL-Diwaniya City that gives the numbers of nodes and pipe

AL-Mowahad project started in the year (1985) with capacity of(66000) m^3/ day.

6. Population Growth in AL Diwanyia City

from the available information at the office of statistics ,one can calculate the percentage of population of Al-Diwaniya city by using formula (4) Annual Rate of Increase Method (1)

$Pn = p\ (1+i)^n$ ….(4)

where Pn: population at the end of n years

P : population at any time

i :annual rate of increase of population

The total of population for the years, 1987,1997 are (185009,231021) respectively, and th e rate of increase becomes as follows:

$$\sqrt[n]{\frac{Pn}{P}} - 1 = \sqrt[10]{\frac{231021}{185009}} - 1 = 0.0224 = 2.24\ \%$$

To estimate the number of population for the year2003, the percentage of increase 2.24% would be chosen for calculating the number of population now. Population for the year 2003 = 278139 = 280000 capita

The number of population in every district of AL-Diwaniya according to the available statistics that for the year 1997, the estimated number of population for the years 2003,2010,2025 depending on the rate of increase 2.2% is shown in table (1).

7. HYDRAULIC ANALYSIS:

There are two-treatment plants supply water in the city, as well asfive compact units. Layout of network contains length and diameter of pipes and position of nodes that supply regions as shown in Fig (2), the actual capacity of these projects is as the follows:

1 .The old treatment plant	19.28MLD
2.pumping station	72MLD
3.AL-Jazzaer compact unit	4.84MLD
4. AL-Escan compact unit	15.84MLD

According to field questionnaire and available head in some of regions, one can get the estimated demand in every region, by using trial and error in the program (pipe ++) to get the heads corresponding to the measured field head, so, the results are classified into three classes:

l.A:450	lpcd	H>15m
2.B: 350	lpcd	H< 15m
3.C:300	lpcd	H=<10m

Table (2), shows the corrected demand (lpcd). One can specify the shortage of water in regions as (300 (lpcd)) limited in public requirements in the city, the regions (K, P, S, T,U) have minimum of head

And the optimum consumption per capita per day (500 lpcd), is given in Table (1) shows the population of AL-Diwanyia city in years (2003,2010,2025) as (278139, 324795, 452815) capita, so that the consumption would be (139.06 MLD) at 2003 and as it was mentioned the actual production for (2003) was (111.96 MLD) .It means that the network suffers from actual shortage of (27.10 MLD) at 2003. If the project lasted for 2010 people would suffer from shortage of (50.43 MLD)

8. ANALYSIS OF WATER QUALITY OF DISTRIBUTION NETWORK IN AL-DIWANYA CITY:

Water that may be considered absolutely pure is not to be found in nature. Even rainwater is in fact, distilled water, which collects impurities such as dust, gases, and bacteria. The portion of rain water which flows over the surface and called runoff picks up organic and suspended matter, whereas the portion percolating through the ground gets mineralogical, organic and inorganic matter that gathers while traversing through the underground strata before reaching the water table level. (doggle 1997).

9. STATISTICAL ANALYSIS OF DATA:

In the statistical analysis, the magnitude correlationexpresses the connection between a series of views for two variables and more: -

Finding the amount of changes that occurs in the concentration of chemical and physical parameters for raw and supply water with the time which is expressed by the monthly concentration starting from January 2002 to December 2002 .The test of F (single factor ANOVA) was made on the chemical concentration and physical parameters for drinking and raw water, see in Fig(2)to Fig(3)

Searching for relation linking between the rate of pollution of tap water and water born diseases.

10.THE PHYSICAL PARAMETERS OF RAW AND SUPPLY WATER IN PURIFICATION PROJECT OF AL-DIWANIYA CITY:

1 Temperature

2. Turbidity

3. Electrical Conductivity (EC)

4. Total Dissolved Solids (TDS)

5. Suspended solids (SS)

11.THE CHEMICAL PARAMETERS OF RAW AND SUPPLY WATER IN PURIFICATION PROJECTS OF AL- DIWANIYA CITY:

1 .pH value
2. Sulphate ($S0_4$)
3.Chlorides (CL)
4. Calcium (Ca)
5. Magnesium (Mg)
6. Alkalinity
7.Total Hardness

12. DISTRIBUTION OF POLLUTED RATIOS OF TAP WATER BASED ON MONTHS

The ratio of pollution represents the polluted samples of tap water divided by the whole number of samples taken in those months in fig (1)

Analysis of variance test results (one way ANOVA) was used to distribute the polluted samples ratios months and results pointed, there were no significant effective months on average of monthly polluted ratios with significant level (0.95).

The reason behind increasing of polluted samples ratios in April and August is the increase of turbidity values, these values were the highest in supply water and that can be explains the caused pollution after treatment or might be because of corrosion in pipes of distribution network or another problem in distribution.

13. THE ECOLOGICAL EFFECT OF BACTERIOLOGICAL POLLUTED WATER ON TRANSFERRED DISEASES VIA WATER:

Diseases studied were cholera,infectious hepatitisA(Jaundice), amoebic,desentery(amoebiasis), SalmonellaTyphoid,Giardiasis for AL-Diwaniya City for year 2002 con-elated with polluted samples ratios in that year .Table (3)gives the number of infections states related to these diseases for year 2002.

The relation was examined between the number of infections with diseases transported through water and the ratios of pollutant of tap water. This relation is shown in table (4):-

The table above show that there is a good significant relation between the ratios of pollution of tap water and typhoid in August. This means that the correlation between two variables is important.The reason behind that is the pollution in network as a result of break in one of pipes , leakage that happens in connection, valves.

The distribution network in some regions collects the sediments, and many breaks happen in the pipes that lead to fluctuation of supplied water in these regions (as in F, Q, O, R).Fig (1)

Population of AL-Diwaniya City in 1997 is (243521) and percentage of increase is 2.24%, then number of population for 2003 would be equal to (278139), the maximum consumption per capita per day is (500 lpcd) , so total consumption would be (139.06MLD),and

as is mentioned , the actual production for (2003) is (111.96 MLD) from all treatment plants . It means that-the network suffers from actual shortage equals to(27.10MLD).

Pressure analysis in the network shows that 50% of the nodes are in agreement with the measured field pressure. The network can be classified into three area classes and their regions:

A: 450 lpcd ,H >=15m , (A,B,D,E,G,I,N)
B: 350 lpcd , H< 15 m , (C,F,H,J,,L,M,0,Q,R)
C: 300 lpcd , H< = l0m , (K,P),(S,T,U)

Variance analysis test in one way (ANOVA), shows a significant difference among the months covered in this research for monthly averages concentrations for variables (TC, NTU, SS, EC, TDS, SO_4, CL, Ca, Mg, TH) for raw water. The reason behind that is the increasing in concentrations of variables during months. The main reason for this increase is related to either the climatic differences among months or to the decrease in the flow quantity of the river due to drought and few rainfalls.

There is no significant difference among research months in terms of monthly average of pH concentration of raw water. The reason is that may the variables are not affected by climatic difference in months during drought and small rainfalls. So raw water is considered within the allowable limits and suitable to produce drinking water.

Monthly averages for (Turbidity, Total hardness, Sulphate, Calcium) of drinking water are more than the acceptable limits according to the national specification number 417 for 1974 and

International specification (WHO, 1984), and water can be classified as acceptable to weak according to (TDS).

Samples of tap water were collected from the regions of network then checked in the lab. The United treatment plant in order to measure the residual chlorine as a guide to bacteriological pollution .The chlorine ranges between (2.5-0.75) mg/1.

Although drinking water has a good quality, Pollution State may happen in any part of network because of leakage and breaks. Moreover, five water born diseases which are transferred through water were studied (Cholera, infections hepatitis A (jaundice), amoebic, desentery (amoebiasis), salmonella, typhoid, giardiasis) correlated with polluted samples ratios in 2002.

The result shows that there is a good significant relation between the ratios of pollution of tap water and typhoid during August (111 infectious).

15. RECOMMENDATIONS

1. Replacement of all the damaged pipes in the distribution network especially in those regions that suffer from shortage, and managing a periodic maintenance on the distribution network to discover breaks in the pipes for repairing and avoiding any pollution in the network.(F,Q,0,R)
2. Building compact unit with designed capacities enough for the city up to 2010 and equal to (50.43 MLD) according to increase in population and to meet maximum demands.

3. Building new projects for purification of water with design capacity enough for 2025 with capacity of (226.40 MLD).
4. Controlling alum doses into coagulation basins using scientific means to increase the settlement efficiency.
5. Increasing efficiency of rapid sand filters in the projects by doing required maintenance operations to ensure quantity and quality of sands in these filters. Also the continuous cleaning should be made to avoid accumulation of alga groups especially when there is alga booming problem in the Euphrates River.

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Table(1): The estimated number of population for2003-2010,2025 [10].

No.	District names	symbol	Pop. 1997	Pop.2003	Pop.2010	Pop.2025
1	ALUruba,zawra	A	30259	34560	40357	56264
2	AL-Saray	B	6430	7344	8576	11956
■5	West AL-Jumhuri	C	4636	5295	6183	8620
4	AL-Furat	D	7346	8390	9797	13659
5	AL-Askaree	E	30801	35180	41081	57273
6	AL-Askan, Jameia	F	5403	6171	7206	10046
7	Rafaat, jela	G	16810	19200	22421	31258
8	East AL-Jumhuri	H	13833	15799	18450	25722
9	Eskan AL-Senaee	I	10254	11712	13677	19068
10	AL-Jedaida	J	6060	6922	8083	11269
11	AL-Asree	K	6697	7649	8932	12453
12	AL-Suq	L	13400	15305	17872	24916
13	AL-Thubat	M	4646	5307	6197	8640
14	AL-Jazzicr	N	4707	5376	6278	8753
15	14 Ramadan	0	6268	7159	8360	11655
16	AL-Shamiya side	P	6808	7776	9080	12659
17	AL-Wahda	Q	43659	49865	58230	81182
18	AL-Nahtha	R	25504	29129	34015	47422
19	AL-Sanaay	S	-	-	-	-
20	Garage	T	-	-	-	-
21	University	U	-	-	-	-
22	Total		243521	278139	324795	452815

Table(2):corrected demand and corrected head in each node for year 2003

No.	symbol	class	Av. Demand (lpcd)	Pop.2003	Corrected demand(l/s)	Node no.	Measure Head m	calculated head m
1	A	A	450	34560	180	26	24	46.3
2	B	A	450	7344	38.25	33	32	35.8
3	C	B	350	5925	24	25	10	10.9
4	D	A	450	8390	43.7	6	20	21.9
5	E	A	450	35180	183.2	8	21.5	18.7
6	F	B	350	6171	25	15	12	13.7
7	G	A	450	19200	100	21	20	49.7
8	H	B	350	15799	64	24	9.4	10.9
9	I	A	450	11712	61	16,17	18.5	18.1.36.7
10	J	B	350	6922	28.1	32	15	18.4
11	K	C	300	7649	26.6	31	5.2	5.4
12	L	B	350	15305	62	23	10.3	12.4
13	M	B	350	5307	21.5	11	15	14.5
14	N	A	450	5376	28	40	30.7	32.4
15	O	B	350	7159	29	42	10	10.4
16	P	C	300	7776	27	43	8.2	8.7
17	Q	B	350	49865	202	7	11.7	17.3
18	R	B	350	29129	1 1 8	14	13.8	13.7
19	S		-	-	10.4	46	1	0.1
20	T		-	-	24	45,41	1	0.5
21	U		-	-	17	44	5	6.1

Shortage of water in region observed in high lighted raw.

Table(3): number of infection case with these diseases.

months	*Diseases*				
	Amoebiasis	Typhoid	Giardiasis	cholera	Jaundice
Jan	31	15	30	1_ 0	19
Feb	33	19	33	5	10
Mar	38	27	45	0	13
Apri	64	93	83	0	22
May	104	92	105	3	15
Jun	59	87	91	2	21
July	52	60	48	2	39
Aug	34	111	48	1	28
Sep	44	84	57	0	7
Oct	67	73	65	0	18
Nov	91	71	61	1	27
Dec	75	49	66	0	7

Table(4): correlation (r) for all diseases.

Diseases	Correlation(r)	Degree of importance
Amoebiasis	0.038	not significant
Typhoid	0.730	significant
Giardiasis	0.152	not significant
cholera	0.039	not significant
Jaundice	0.244	not significant

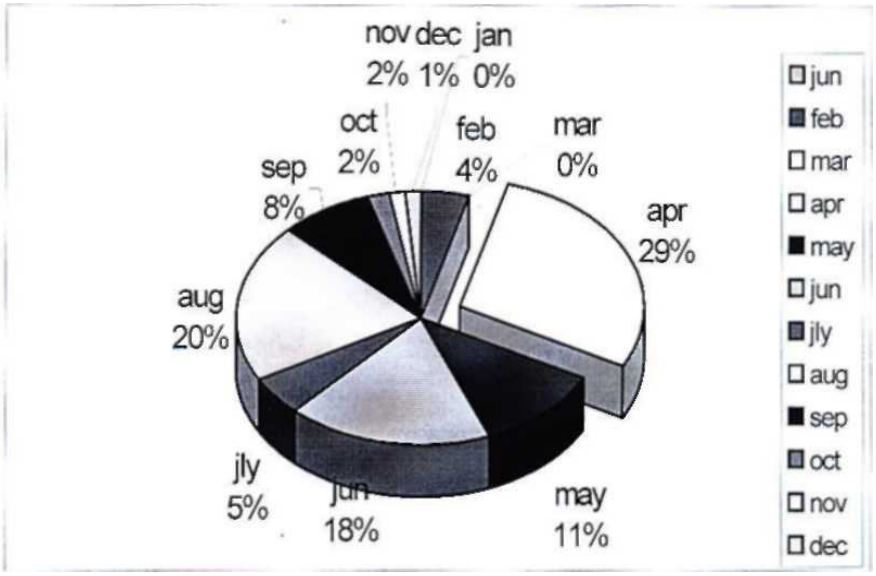

Fig.(1): Distribution of polluted ratios of tap water based on months.

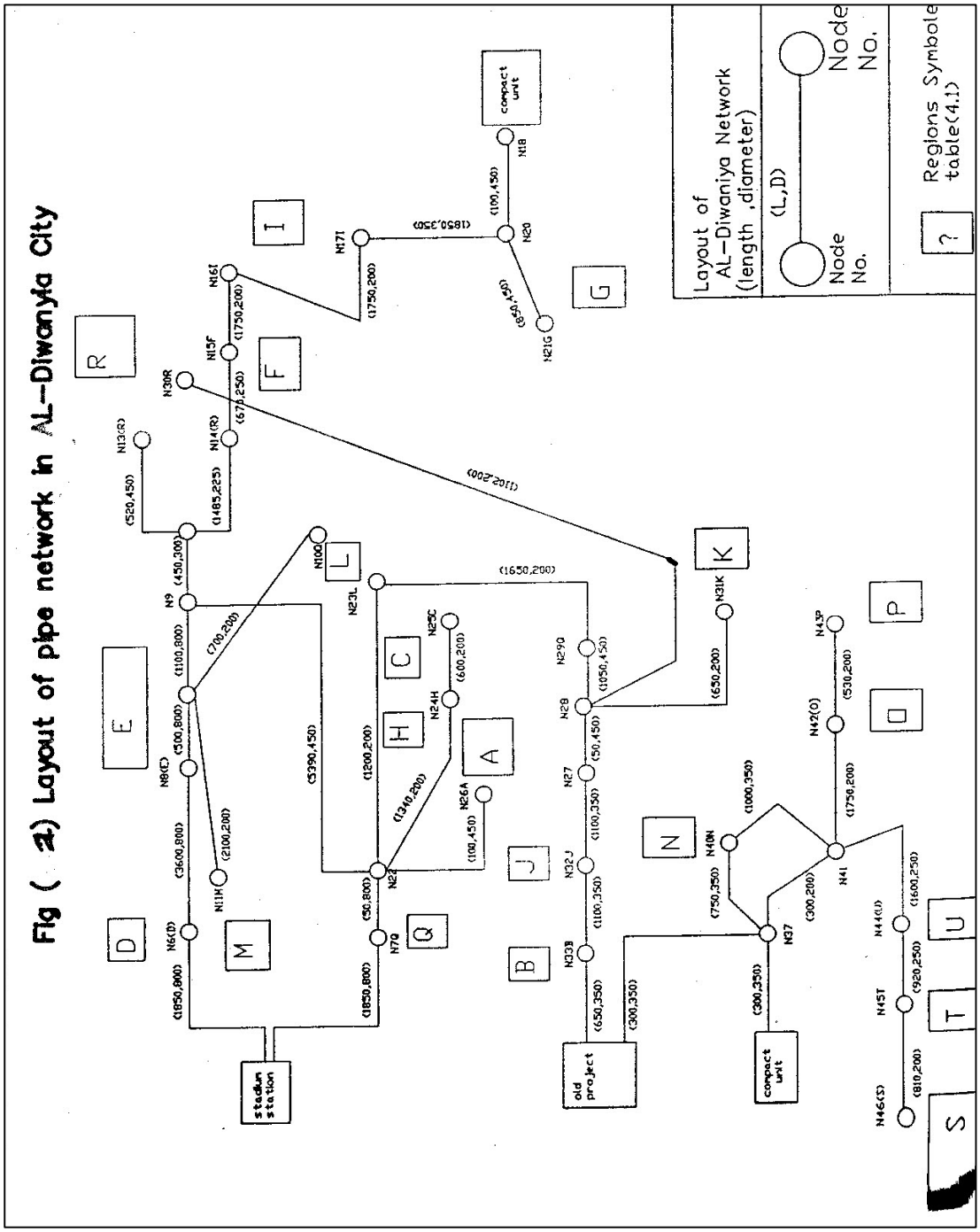

Fig.(4): Layout of pipe network in AL-Diwanyia city.

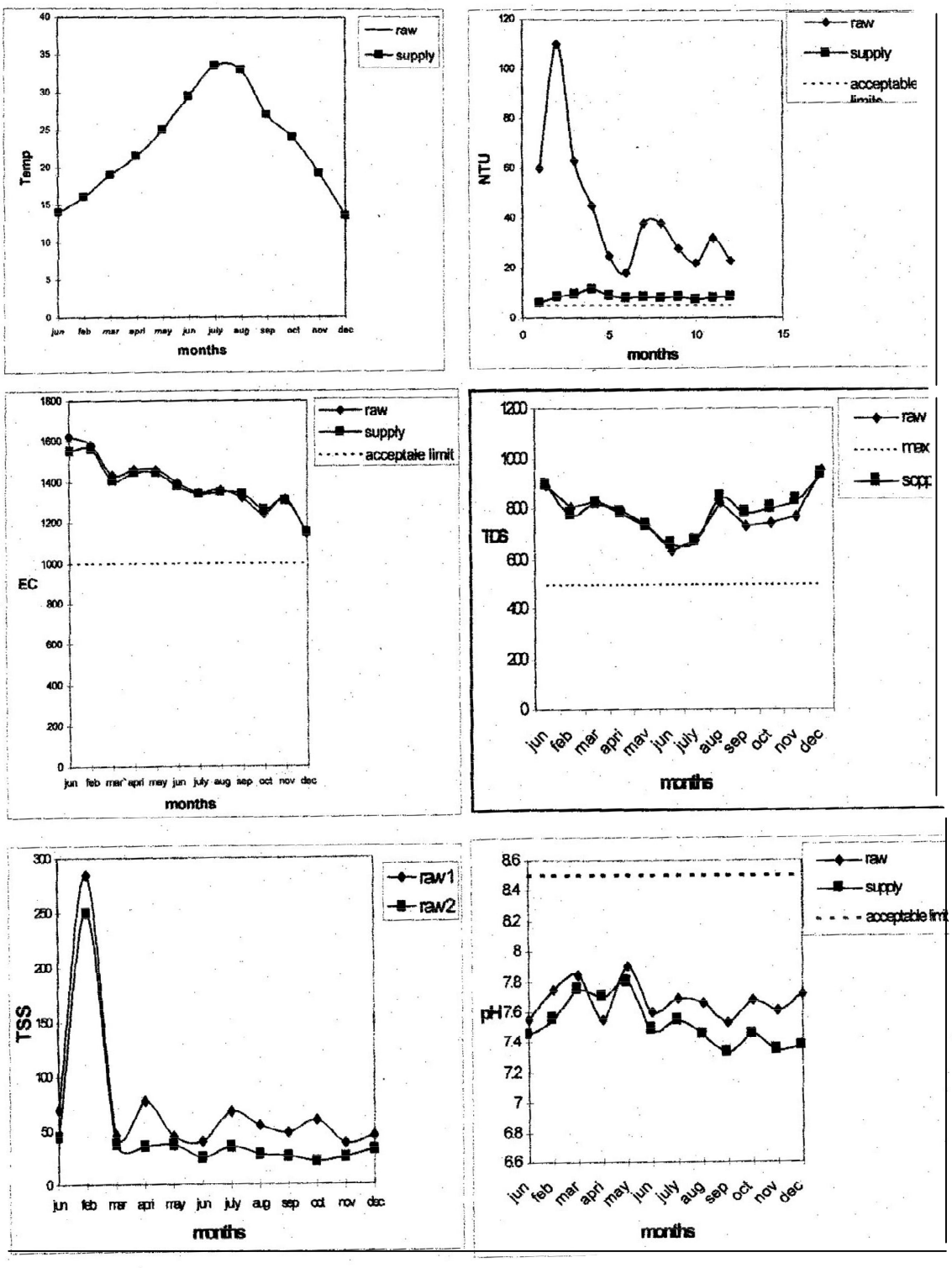

Fig.(3): monthly average of physical Features of Raw & supply water.

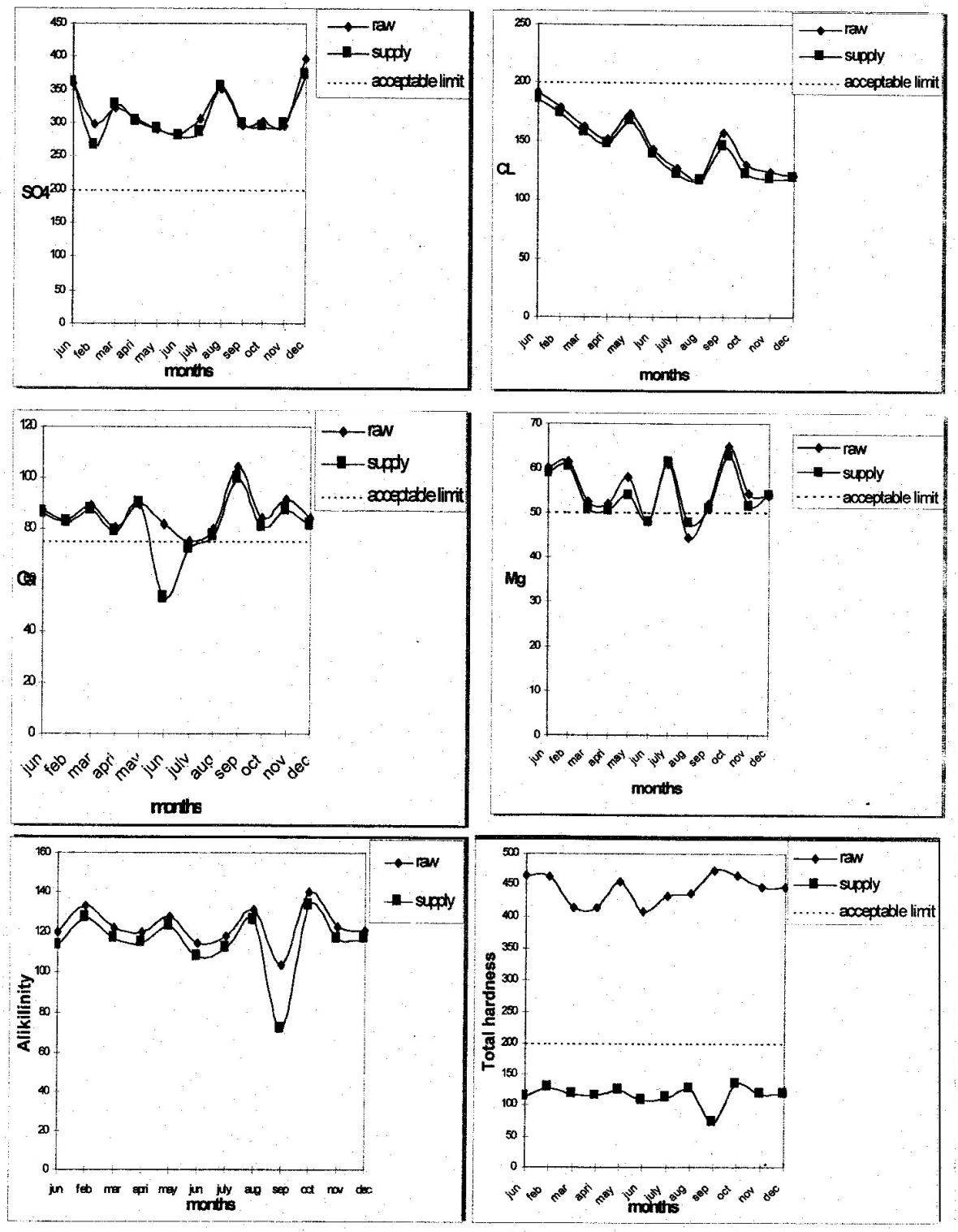

Fig.(4): monthy average of chemical Features of raw and supply water.

تحليل و تقييم شركة الماء الصافي و نوعية المياه في مدينة الديوانية

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الخلاصة

في هذا البحث تم دراسة واقع خدمات المياه في مدينة الديوانية ، اذ تم اخذ محورين اساسين :-

الاول: تم تحليل شبكة الانابيب الناقلة في المدينة بأستخدام برنامج (++ pipe) اصدار ١٩٩٨ لمعرفة التصاريف و اتجاهاتها المارة في الانابيب الرئيسية من الشبكة و استخدام الضغوط الحقلية التي تم قياسها في نقاط معينة من الشبكة لتخمين استهلاك الشخص الواحد في كل منطقة و تحديد المناطق التي تعاني من الشحة و اسبابها و الاقتراحات اللازمة للتقليل منها .

الثاني : تقييم ملائمة الماء الخام لأستعمالها كمصدر لمياه الشرب و تقييم المياه المقاة في المحطات ،فقد اخذت عينات لمياه الشرب من محطة التنقية اضافة الى عينات من ماء الحنفية لكافة المناطق في المدينة بتاريخ ٢٠٠٣/٧/٢٦ و قد تم تحديد الامراض الانتقالية التي تسببها مياه الشرب و حصر اعداد الذين اصيبوا بهذه الامراض خلال عام ٢٠٠٣ و ربطها بنسب ماء الحنفية الملوث خلال الفترة ذاتها

و قد اجريت التحاليل الاحصائية (تحليل التباين و تحليل الارتباط) و كانت النتائج كالاتي :

-من مقارنة المعدلات الشهرية للمتغيرات الفيزياوية و الكيميائية للماء الخام مع الحدود الواردة في بعض المواصفات الدولية المعتمدة للمياه السطحية يمكن عد نوعية الماء الخام جيدة و انها ملائمة لغرض استعمالها كمصدر لأنتاج مياه الشرب بعد تنقيتها في المشاريع التقليدية لتصفية الماء كما ان مياه الشرب المنتجة كانت صالحة للاستهلاك البشري لكونها ضمن مواصفات مياه الشرب العراقية و الدوليه المعتمدة على الرغم من تجاوزها الحد المقبول لكل من (الكدرة ،العسرة ، الكبريتات ، الكالسيوم) لكنها اقل من الحد المسموح .

- وجود علاقة معنوية جيدة بين نسب تلوث ماء الحنفية و مرض التايفوئيد خلال السنة .
- توجد علاقة معنوية بين مرض التايفوئيد و النوعية البكتريولوجية للماء المجهز من المحطة .
- نسبة الكلور المتبقي لكافة المناطق و بعد الفحص المختبري تتراوح (٠,٧٥ – ٢,٥) ملغم/لتر .