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Evaluation of The Efficiency of Disinfection of Drinking Water in Kufa City

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ABSTRACT

Drinking water chlorination is one of the most significant advance in public health protection. Besides, chlorine-based disinfectants are the only major disinfectants with the lasting residual properties that prevent microbial regrowth and Provide continual protection throughout distribution system from the treatment plant to the final consumer.

In this study it was evaluated the efficiency of the sterilization of drinking water in the water supply network of Kufa city, water samples were taken from seven locations distributed over the city and these samples checked in the morning and evening to identify the concentration of chlorine in all its forms (total residual, free residual and combined) , in addition to the follow up to the concentration of chlorine in the same projects processed water for the city as well as to identify the quantities of doses of chlorine added in these projects. Then the results obtained from the concentration of chlorine were compared with the specifications in order to identify the process of sterilization of water in water projects in the city.

الخلاصة:

تعتبر عملية تعقيم المياه إحدى أهم الإجراءات الهادفة إلى حماية الصحة العامة. إضافة إلى ذلك فان المعقمات التي يكون الكلور أساسياً فيها هي المعقمات التي تمتلك خواص البقاء إلى ما بعد عملية التعقيم بذلك تقدم حماية مؤكدة ومستمرة للمياه بدءاً من محطة التصفية وصولاً إلى المستهلك النهائي.

في هذه الدراسة تم تقييم كفاءة تعقيم المياه في شبكة إسالة المياه لمدينة الكوفة، حيث تم اخذ عينات من المياه من سبعة مواقع موزعة على المدينة وتم فحصها صباحاً ومساءاً للتعرف على تركيز الكلور بكل أشكاله (المتبقي الكلي ، الحر المتبقي والمتحد) بالإضافة إلى متابعة تراكيز الكلور في نفس المشاريع التي تجهز المياه للمدينة وكذلك التعرف على كميات الجرع المضافة من الكلور في هذه المشاريع، ثم تم مقارنة النتائج التي تم الحصول عليها من تراكيز الكلور مع المواصفات الخاصة بها من اجل التعرف على سير عملية التعقيم للمياه في مشاريع المياه في المدينة.

1- INTRODUCTION

The availability of a water supply adequate in terms of both quantity and quality is essential to human existence. Early people recognized importance of water from a quantity viewpoint. Civilization developed around water bodies that could support agriculture and transportation as well as provide drinking water. Recognition of the importance of water quality developed more slowly. Early humans could Judge water quality only through the physical senses of sight taste, and smell. Not until the biological, chemical and medical sciences developed were methods available to measure water quality and to determine its effects on human health and well-being(Peavy,1985).

As civilization evolved, human activity increased the amount and changed the nature of pollutants entering watercourses, water pollution is the changed in physical, chemical and biological characteristics water (all or some) lead to change water quality and lead to make water unsuitable for drinking.

To purify water, physical, chemical and biological processes should be work in engineered systems like coagulation, sedimentation, filtration and disinfection.

Disinfection of water is the killing of disease-causing microorganisms that it may contain. Chlorine, in its various forms, has been widely used in disinfecting water. It is cheap, reliable, and presents no great difficulty in handling (Steel,1979).

But this is the fact that the chlorine is toxic and hazardous and should be treated with caution and added water should be more scientific and thoughtful.

Chorine, the most common disinfectant in the US, is effective in killing most pathogenic bacteria and viruses. Municipal potable water supplies are usually chlorined to provide a residual concentration of (0.5 to 2.0) PPm. (Edstrom industries, 2003).

The objective of the search is assessing the efficiency of drinking water sterilization in Kufa city for the purpose of identifying the success of this process and conform to the specifications of its own because of this process of great importance and directly in human life and health.

1.1 Chlorination

Chlorine may be applied to water in gaseous form (Cl_2) or as an ionized product of solids [Ca(OCl)2, NaOCl]. The reactions in water are as follows:

$$Cl_2 + H_2O \rightarrow H^+ + HOCl$$

$$Ca(OCl)_2 \rightarrow Ca^{+2} + 2\ OCl^-$$

$$NaOCl \rightarrow Na + OCl^-$$

The hypochlorous acid (HOCl) and the hypochlorite ion (OCl) in the above equations are further related by :

$$HOCl \rightleftharpoons H^+ + OCl^-$$

A relationship governed primarily by PH and temperature.

The sum of HOCl and OCl^- is called the "free chlorine residual" and is the primary disinfectant employed (Peavy, 1985).

The chlorine in water in chemical combination with ammonia or other nitrogenous compounds which modify its rate of bactericidal action is known as the combined available chlorine.

The chlorine demand of a water is the difference between the amount of chlorine added and the amount of chlorine present as a residual (steel,1979).

2 THE AREA STUDY

Kufa city is situated at the south of Iraq (The mid-Euphrates region). It is situated between ($32^o\ \bar{0}4$ -32^o) northern longitude and ($44^o\ \bar{2}6$ -$44^o\ \bar{2}3$) eastern latitude. Euphrates river limits Kufa city from east side and Al Najaf city situated on right side. It is an old historical area date-palms are the common and famous type of trees planted in this area.

2.1 Drinking Water Treatment Projects in Kufa City:

The city containing two water purification and source of raw water to the processor is the Shatt Al-Kufa. Fig (1) shows the projects locations in the city and the main lines of the distribution network.

Kufa Old Project: *

Kufa project was founded on the shore of the Euphrates River in the district of Kufa in year 1967. It was established by Ali Cola Company with (Polish-Kurdish) design. The number of the people served by the project (170000 Capita) and with discharge (1000 m3/hr) . The project contains four pumps and two sedimentation tank. The length of the network is (250 km) and the diameters of the pipes are (1m) for the main carrier tube, and (250, 300 ,350, 450, 600, 900 mm) for branch pipes. Then the project is expanded by adding one pump with discharge ($500m^3$/hr)

*** There is an old project was founded in 1954, but now suspended from work.**

Drinking Water Treatment Project in Al Zerkh:

Al Zerkh plant is located in the northern city of Najaf on the shore of the Shatt Al-Kufa, which is one of the tributaries of the Euphrates, specifically in the area was called Al-Zerkh. Calculations were carried out and planning for the construction of the project was held in the seventies to cover the cities of Najaf and Kufa so called Najaf-Kufa draft Common. The energy design of the project was 200000m3/day (9000 m3/hr) and to cover the needs of citizens at 350 liters per person, but that works is starting in the project (1986) and lasted for ten years then, work stopped because of the Gulf War a few years.

Plant began operation in (1996) and the plant began experiencing serious problems in the year (1999) because of lack of preventative maintenance and arbitrary operations until reaching efficiency 50% from efficient design after the events of the recent liberation of Iraq, becoming the station suffered from a lack of efficiency on the one hand and it was inadequate to cover the population growth on the other.

Then the US Agency for international Development (USAID) and by the Bechtel International Systems States in the rehabilitation of water project Al-Zerkh so as to serve the Iraqi cities a large part of building the infrastructure of Iraq and continued the work approximately two years.

Initial pumping station (lift station) consists of nine pumps withdraw water from Shatt Al-Kufa (six pumps to work and three to support) of each of these pumps capacity (125 kw) and capacity (1500 m3/hr).

Because the distribution system is long and complex, the chlorine will be distracted and that the process of re-sterilization is necessary, and thus add chlorine in several areas of the water system to ensure the survival of the amount of chlorine in the water until the arrival of the consumer (Al-Ghaliby,2005) .

3- EXPERIMENTAL WORK

In the present study, water samples were taken from seven locations distribution on the Kufa City and its districts as indicated in Fig.1. The water samples were analyzed for chlorine test. Samples locations are shown in Table 1 with the project processing to each location.

Table 1 . Sampling Locations With the Project Processing to Each Location.

Order	Location	Location Symbol	The project processing
1	Old Kufa	A	Kufa Old Project
2	Maitham Al Tammar District	B	Kufa Old Project
3	Kinda 2	C	Kufa Old Project
4	Kinda 1	D	Kufa Old Project
5	Euphrates Hospital	E	Kufa Old Project
6	Meesan 1	F	Al-Zerkh Project
7	Meesan 2	G	Al-Zerkh Project

The study lasted for two months from 15/12/2008 to 15/2/2009, samples were taken and examined in a three days a week morning and evening. A.m. samples examined (at the limits of the eight to the tenth hour) and evening (at the limits of the third to fifth hour) to ensure the presence of chlorine in the water morning and evening. As indicated in the Tables 2 and 3.

3-1 Sampling:

The samples taken from locations shown in Table 1 were analyzed for chlorine test local and directly after taking them from the source because chlorine material quick evaporation and enable store the samples. Lovibond instrument which depends comparative color method was used to determine chlorine concentration in water. Detector (N-N Diethyl –P-Phenylene Diamine DPD) was used to react with chlorine and gives colors range from dark pink to light. One DPD-No. was used to determine concentration of free residual chlorine in mg/ℓ and three DPD-No. to determine concentration of total residual chlorine in mg/ℓ. The difference between these two reading gives concentration of combined chlorine in mg/ℓ.

3-2 Results:

After the completion of a testing site and the results, these result were ordered in tables as shown in Tables 2 and 3 for the samples examined in the morning and evening, also these results were represented in relations represent extent of the change in concentrations for all forms of chlorine (total residual, free residual and combined chlorine) with the time during the study period and for the samples examined in the morning and evening as in Figs. 2 and 3 . The free residual chlorine concentrations were represented in relations with the time and for the samples examined in

the morning and evening during the study period and these concentrations were compared with the specifications allowed (which dependent by the Department of Environmental Protection and the Department of Health in the examination of residual chlorine) , as in Figs. 4 and 5.

Table 2. Values of the Concentrations of the Total Residual, Free Residual and Combined Chlorine for the Samples Examined in the Morning.

Location Symbol	Free Residual Chlorine		Total Residual Chlorine		Combined Chlorine
	Average	Range	Average	Range	Average
A	2.9	(2-3.5)	3.6	(3-4.5)	0.7
B	2.9	(2.25-3.25)	3.7	(3.5-4)	0.8
C	2.6	(2-3)	3.6	(3-4)	1
D	2.8	(2.5-3.5)	3.6	(3.5-4)	0.8
E	2.2	(1.25-3)	2.6	(1.5-3.25)	0.4
F	0.26	(0.05-0.75)	0.4	(0.2-1)	0.14
G	0.3	(0.2-0.5)	0.59	(0.4-0.8)	0.29

Table 3. Values of the Concentrations of the Total Residual, Free Residual and Combined Chlorine for the Samples Examined in the Evening.

Location Symbol	Free Residual Chlorine		Total Residual Chlorine		Combined Chlorine
	Average	Range	Average	Range	Average
A	2.75	(2.25-3.5)	3.6	(3.5-3.75)	0.85
B	2.6	(2-3)	3.5	(3-4)	0.9
C	2.2	(2-2.5)	3.25	(2.75-3.5)	1.05
D	2.5	(2-3)	3.3	(3-3.5)	0.8
E	2	(1.25-3)	2.4	(1.5-3.5)	0.3
F	0.24	(0.05-0.5)	0.32	(0.2-0.5)	0.08
G	0.24	(0.1-0.5)	0.51	(0.35-0.8)	0.27

4- DISCUSSION AND CONCLUSIONS;

By observing the results shown in Fig.2 and 3 for the samples examined in the morning and evening and all the locations studied, it was noted the irregular and fluctuation of the concentration of chorine in all its forms (total residual, free residual and combined), we also note the high values of the concentration of chlorine of the samples examined in the morning on samples examined in

the evening and this is due to the addition of chlorine to the water in the morning, which will lead to higher concentration in the morning, in addition to the high air temperature at the time of the back and the evening leads to speed the evaporation of chlorine from the water added to .

During the study period, it was noted that the lower concentration of chlorine in the locations (G) and (F) (two locations at the beginning and end of Meesan District) which are processed by the water from Al_zerkh water project as shown in Fig1. The reason for the lack of concentration of chlorine in these two locations to the low amount of chlorine added to water in Al-Zerkh water project (1 ppm) in addition to the possible existence of cracks in the pipelines of water network. Al-Zerkh water project serves Al_Najaf City as well as processes the water to Meesan district returning to Kufa City and chlorine is added again in the strengthen station (on the road Najaf- Karbala near the motor shows) before the arrival of water to the Najaf City.

For locations A,C,D, and E, it was noted that the rates of the chlorine concentrations decrease with distance from the source processing (Kufa Old Project), where it was noted that the highest concentration of chlorine is in the (A) location, a location in the old city (the location closest to the Kufa water project) and less concentration of chlorine gradually in location (D) (Kinda 1 location), in location (C) (Kinda 2) and in location E (location of Euphrates hospital), where increase distance a way from the processing source, because of the fact that the rapid evaporation of chlorine and less concentration with time.

The reason of the high average of Concentrations of chlorine in location B (Maitham Al Tammar district location ,despite the distance of the location due to the fact that the path of the carrier pipe water from the project fitted and free of turns and change direction as the pipe passes behind the district without enter to it ,as shown in Fig 1 and this leads to the rapid arrival of water to the location , which is located at the end of this district and therefore affect the concentration of chlorine On the other hand ,may due to the carrier pipe free of cracks ,defects and this helps to maintain the concentration of chlorine and it does not lose..

By comparing values of the concentration of free residual chlorine in the morning and evening and all locations Figs. 4 and 5 with values of the specification adapted by the Department of Environmental protection and the Department of Health in the examination of the residual chlorine in the waters of the network, we note that the free residual chlorine concentration of locations A, B, C, D and E higher than the specifications values and for the samples are examined in the morning and evening.

The Interpretation of the high values of concentration free residual chlorine at the locations from A to E is due to increased doses of chlorine added in Kufa old project (the processor of the

locations above) during the study period, the amount added was range from (3.5-4ppm) due to the speed of cholera during the study period, while the added in normal circumstances (2.5-3ppm).

The average values of the concentrations of free residual chlorine in Kufa Old Project during the period study was (3.5ppm).

Chlorine has a great capacity to sterilize drinking water and used for this purpose for more than a hundred years as chlorination to kill all pathogenic bacteria, including the causes of diseases, typhoid, cholera and aldessantarya, but specialists to worry about the material resulting from the interaction of chlorine with organic materials and known as hydrocarbons or (Trihalomethances) and shortened known (THMS), and most of these materials consist in drinking water when chlorine reacts with natural materials such as the remnants of trees decaying and animal material and such material has proven relationship to certain diseases, especially cancer of the kidney and bladder.

As well as at locations from (A) to(E) it was noted that the concentrations a.m. far more about the specifications from concentrations taken in the evening, due to the fact that the rapid evaporation of chlorine and less concentration with time.

In location (F) it was noted that the free residual chlorine concentration in the morning and evening is less than the values of specifications, this is due to the lack of chlorination added in the source processing, and in location (G) we note that most values of the concentrations of free residual chlorine residual are within specifications and possibility of this return to this location near to the source processing more than location F as shown in Fig. 1.

The concentration of total residual chlorine and combined chlorine in locations (G and F) are volatile, time in the specifications and in the other time more and less than the specifications.

Finally, for locations A,B,C,D and E we find that the concentrations of chlorine in all its forms (total residual chlorine, free residual chlorine and combined chlorine) are high values and are not in conformity with the specification for the values of the concentration of chlorine in drinking water as shown in Table 4.

Table 4. The Permitted Limits of the Concentrations for Total Residual, Free Residual and Combined Chlorine . (Metcalf,1979)

Free Residual Chlorine ppm	Total Residual Chlorine ppm	Combined chlorine ppm
0.2- 0.5	0.5 - 0.8	0.3

This indicates that the added doses of chlorine in Kufa water project for the purpose of sterilization are high, in all cases the added chlorine for the purpose of sterilization must be

calculated and scientific deliberate of each aspects to give beneficial concentration of chlorine in killing bacteria in one hand and little damages in terms of diseases, mainly cancer on the other.

5- RECOMMENDATIONS:

1) An addition of the sterilization substance (hypochlorite and chlorine) in the drinking water purification projects in Kufa City must be calculated and deliberate in good science, whether normal cases or outbreaks of disease to obtain concentration of free residual chlorine in conformity with the specifications, this give a positive effect on public health on the first and on the economic costs which will decrease because the best use of chlorine in the sterilization process.

2) Through the study showed that the concentrations of free residual chlorine in Meesan district (returning to Kufa City) very few that we recommend to increase the added doses of the sterilization substance in AlZerkh Project (the project that would serve the district) to maintain the safety of the citizens living in this district in particular that the period of the study was emergency period of numerous cases of cholera.

3) Propose alternative methods of sterilization will lead to a reduction of the proportion of chorine and compounds associated to it in drinking water, and the most important compounds of Trihalomethanes (THMS), which is proven in many studies serious impact on health caused by diseases of cancer, genetic effects and their impact on fertility.

4) Study the various pollutants in drinking water, including various chemical pollutants and compounds associated with the sterilization process, the possibility of the existence of such pollutants in the drinking water is large, so as to provide conditions conducive to the formation of these pollutants, these conditions are the use of large doses of chlorine in the sterilization process and predicted the presence of organic materials for a significant proportion of the fact that the drinking water source of surface water and algae to grow which in addition to the nature of the warm air, which allows the formation of these compounds quickly in drinking water.

5) Water control projects by the authorities and adoption of skilled technical personnel and to sensitizes such personnel through the opening sessions to explain the operations of the purification and the sterilization of water.

6) Make sure to add the sterilization substance in the holiday's days by Department of Environmental protection and department of water for sterile water in each day.

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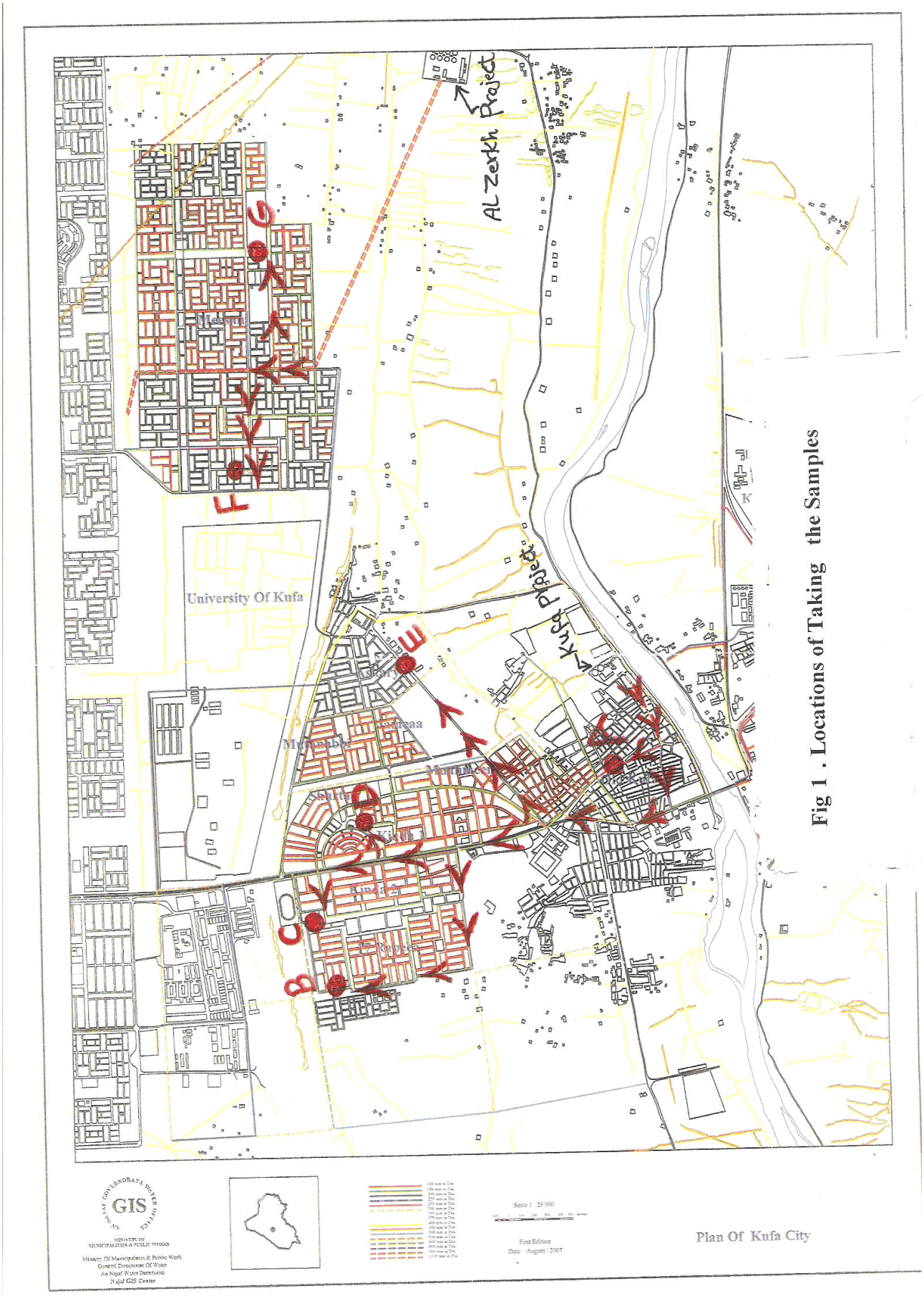

Fig 1 . Locations of Taking the Samples

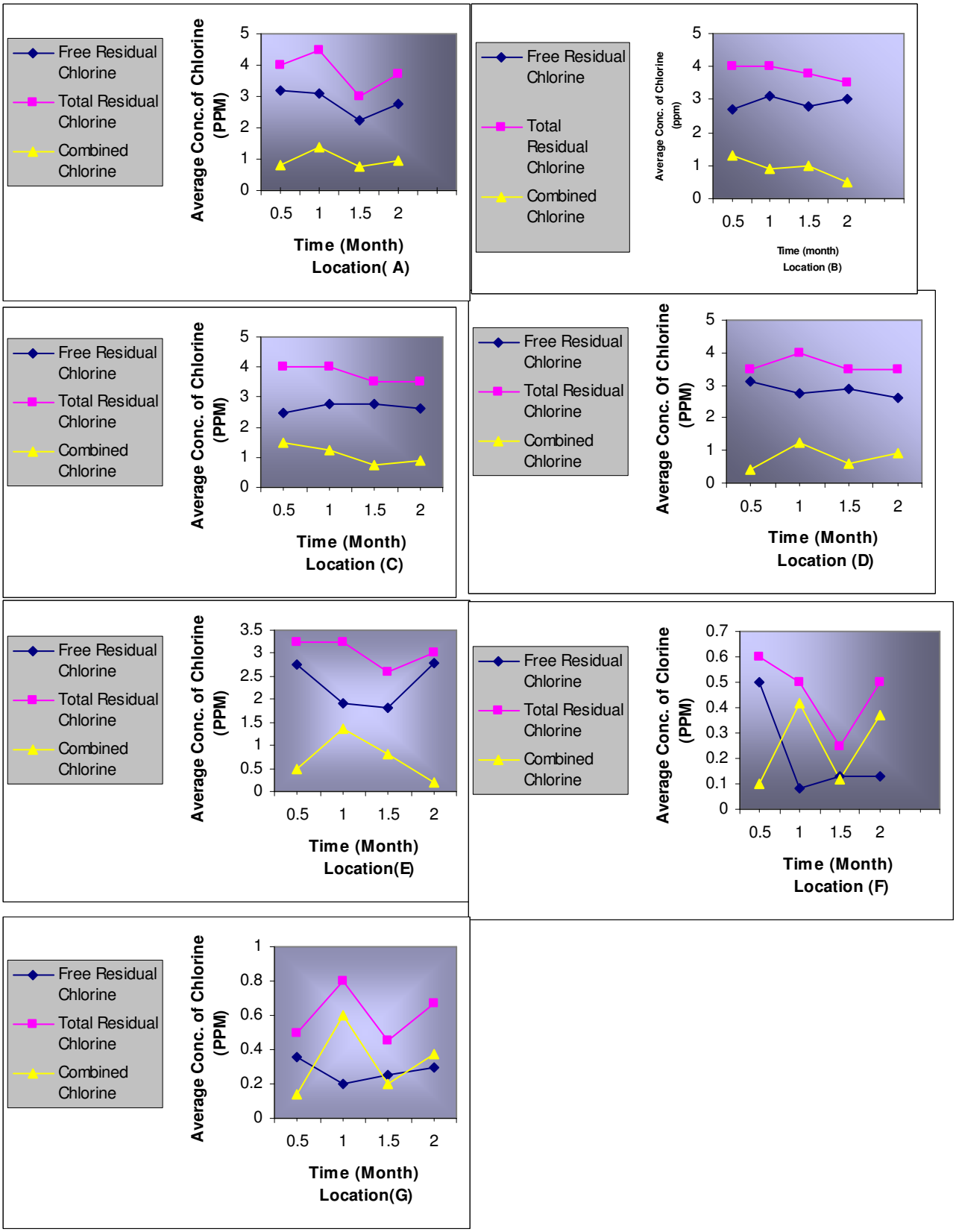

Fig 2. The Relationship Between The Time and Average Concentrations of The Total Residual, Free Residual and Combined Chlorine in PPM for The Locations Above and for The Samples Examined in the Morning.

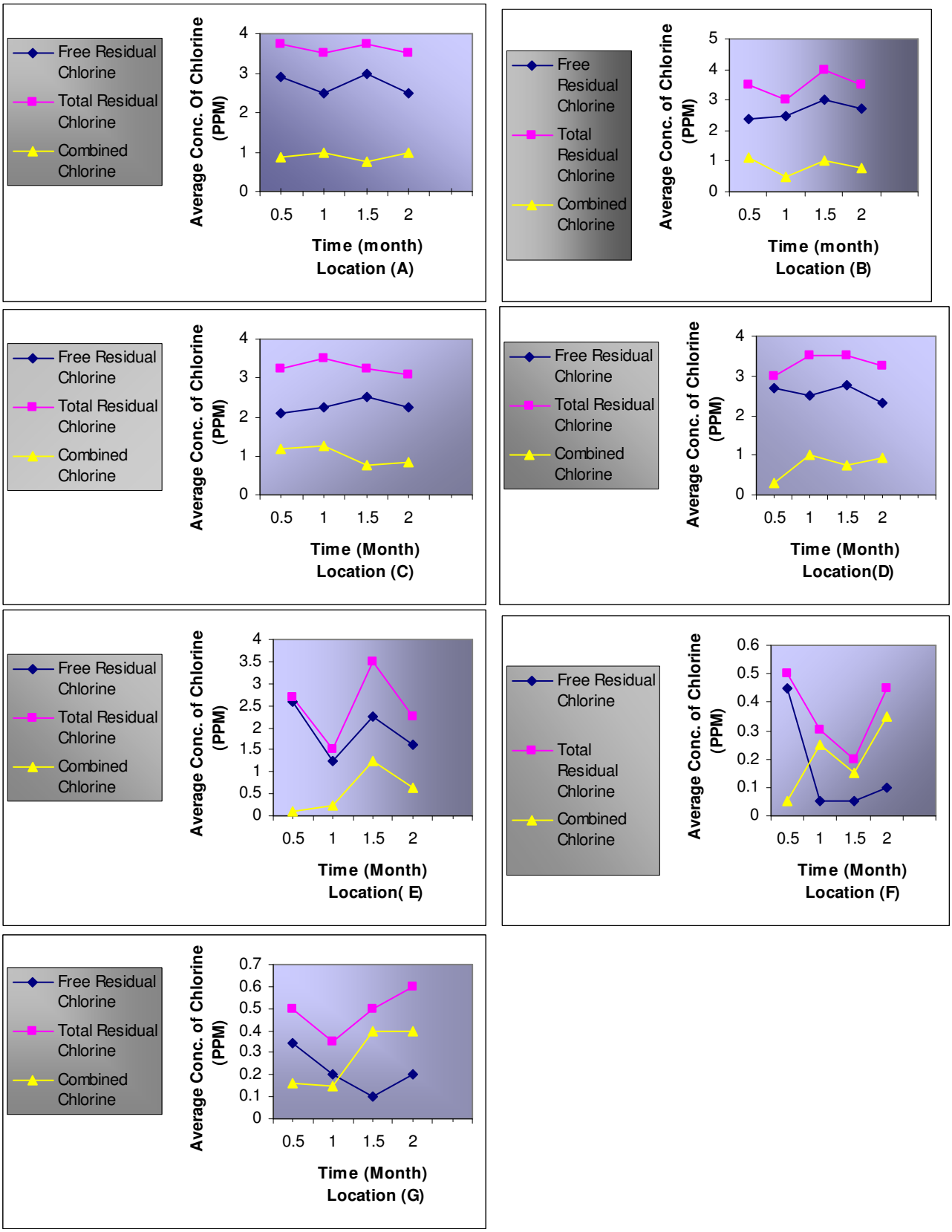

Fig 3. The Relationship Between The Time and Average Concentrations of The Total Residual, Free Residual and Combined Chlorine in PPM for The Locations Above and for Samples Examined in The Evening.

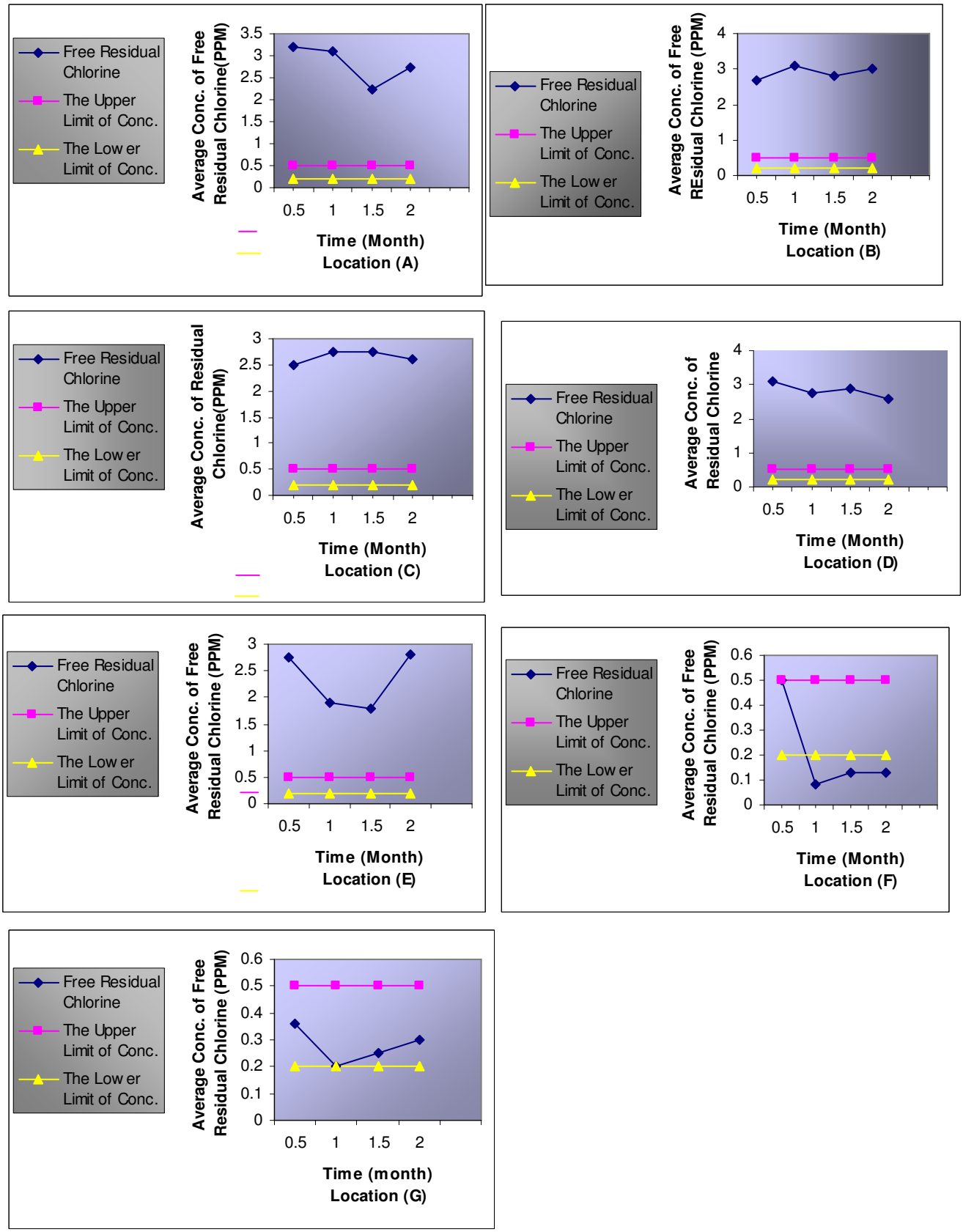

Fig 4. Average of the Concentration of Free Residual Chlorine and the Limits of the Specifications for the Samples Examined in the Morning.

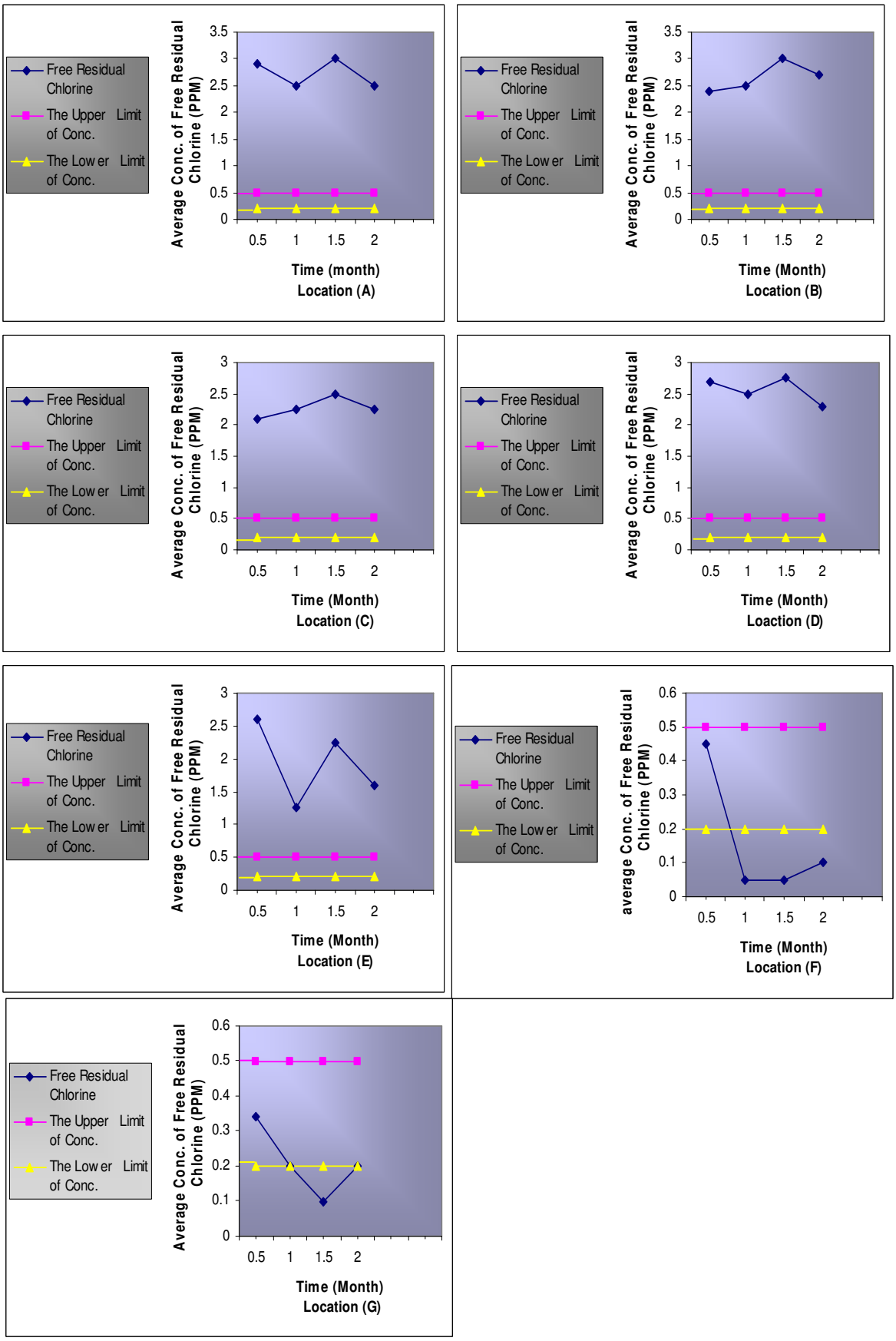

Fig 5. Average of the Concentration of Free Residual Chlorine and the Limits of the Specifications for the Samples Examined in the Evening.