REVIEW AN IMPROVEMENT ON TECHNICAL OPERATION IN DRINKING WATER SYSTEM FOR WATER SUPPLY STATION

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ABSTRACT

Water plays a strategic role in the development of many facilities in our country. Still, the biggest construction projects in the world take place in Iraq with the creation of the most ambitious architectural centers. Great water production plants and distribution networks are constructed and management of available water resources is an important issue. This paper includes the identification of the hazards and introduction of control points that serve to minimize these potential hazards that providing more effect control for drinking water quality. We can conclude that end-product testing is a reactive rather than preventive way to demonstrate confidence in good and safe drinking water. This justifies the need for the formulation of a new approach in drinking water *Quality Control* QC based on understanding of system defense reduces for contamination and on preventive means and actions necessary to guarantee the safety of the water supplied to the consumer. *Water safety plan* WSP is a concept for risk assessment and risk management throughout the water cycle from the catchments to the point of consumption. This work outline and presents an overview of the first year occurrences in the developing and implementing a WSP in the multi- municipal water supply system for a city area of Baghdad. Since key personnel had contributed to the assessment of hazards and evaluation of corrective actions for control points, a greater understanding of water QC and improvements on technical operation and performance have been register, demonstrating good value for the methodology.

الخلاصة

يلعب الماء دورا استراتيجيا في جميع ميادين الحياة المتطورة في بلادنا ومع مواكبة مشاريع البناء والأعمار في العراق، فان عملية بناء وإدارة مشاريع إنتاج الماء وشبكات التوزيع تعد مسالة مهمة. يهتم البحث بالتعريف بالمخاطر المحتملة وإدخال نقاط سيطرة تؤدي إلى التقليل من تلك المخاطر وتوفير رقابة أكثر فاعلية لنوعية مياه الشرب. يمكن أن نستنتج إن اختبار الناتج النهائي يكون فاعلا أكثر مما هو وقائيا لاعتماد الثقةِ في ماء جيد وامن وصالح للشربِ. هذا يُبرّرُ الحاجةَ لصياغةِ وإيجاد معالجة جديدة في إدارة الجودة للماء الصالح للشربِ الذي يستند على فهم نظامِ المناعة ضد التلوثِ والإجراءات الوقائية المطلوبة لضمان صلاحية الماء المجهز للمستهلكِ. خطة ضمان سلامة الماء **(WSP)** هو مفهوم لتقديرِ الخطر والسيطرة عليه, خلال دورة الماء الكاملة من المصدر ولحد الاستهلاك. يقدم هذا العمل ملخص أعمال

التحسين والتطوير للسنة الأولى للأسلوب التقني في تطبيق السيطرة النوعيةِ في منظومة شبكة ماء متعددة الامتدادات لمدينةٍ مثل بغداد. إن المساهمة في تقييم الأخطار والإجراءات التصحيحية لنقاط السيطرة المسجلة أدت إلى فهم وتحقيق قيمة جيدة في استخدام طريقة التحسين في أسلوبQC .

KEY WORDS: drinking water quality control, End- product test risk assessment, source water protection

INTRODUCTION

Drinking water QC is a key issue in public health policies. Special attention and efforts were taken on surveillance and safety of water supply systems that the water as major route of cholera transmission. Later, much legislation published focused on standards for treated drinking water and on compliance monitoring. Water quality was guaranteed by the so called end-product testing, based on spot sampling of the water produced. With this procedure, it was possible to bring the very widespread water-borne diseases under control, especially those of bacterial origin.

Over the years, several shortcomings and limitations of the end-product testing methodology have been identified. Some of them related to the following aspects:

- There is a multitude of water-borne pathogens that cannot be detected or they can be detected insecurely that occurred through water supply systems that met the standard for absence of indicator microorganisms.
- Often, monitoring results are available out of time of intervention needed to maintain the safety of a supply system. End-product testing only allows checking if the water delivered was good and safe (or unsafe) after distributed and consumed.
- End-product testing hardly can be considered a sound method for representative water quality *status*. A very small fraction of the total volume of water produced and delivered is subject to microbiological and chemical analysis. Moreover, the monitoring frequency does not guarantee representative results in time and space, as well.
- End-product testing does not provide safety in itself. Rather is a mean of verification that all the supply system components and installed control measures are working properly.

In recognition of these limitations, primary reliance on end-product testing is presently considered not to be sufficient to provide confidence in good and safe drinking-water, moving towards to process monitoring by introducing a management framework for safe water [Bartram *et al.*, 2001].

Problems

Drinking water research and practice has focused mostly on water delivery infrastructure, treatment technology, specific contaminants, end-product quality and poorly perceived or uncertain understanding of health risks. It is necessary to ask if this focus on technology, engineering practice, end-product quality and immediate reactions to a few specific contaminants is really a rational basis for managing drinking water health risks. Is it the highest or main priority in the provision of safe water? Is the decision making process about drinking water research and practice focused on the most important issues to consumers and their communities? Furthermore, who decides what the issues and priorities are, and are all stakeholders represented or adequately represented in the decision-making processes? It must be asked if the process of setting priorities for drinking water research and good practice is "scientific", rational, preventative and visionary? Most importantly, is safe drinking water consistently available to everyone?

ANSWERS

Actually, the answers to all of these questions are: “No”. The reality is we need to:

- address more of the key issues and questions which influence the condition of safe drinking water,
- re-evaluate and set new and better priorities for drinking water research and practice,
- include more stakeholders in the processes of identifying key issues and setting priorities,
- become more rational and scientific in the overall approach to drinking water research and the provision of safe drinking water,
- become more visionary and anticipatory of the risks to drinking water safety, and
- do a better job of making safe water available, accessible and affordable for all.

In addressing water and health, it is necessary to focus on the fact that water is a fundamental human right for all people, communities and societies, and that human behavior and the process of daily living is inextricably linked to drinking water. These aspects of drinking water and their implications for human health need to be addressed by appropriate research and practice.

THE METHODOLOGY

The proposed methodology request to move away from single dependence on end product testing, which will be integrated into a control strategy for consistently ensuring the safety of a drinking-water supply system, applying a comprehensive risk assessment and risk management approach. The safety of drinking-water depends on a number of factors, including quality of source water, effectiveness of treatment and integrity of the distribution system. System-tailored hazard identification and risk assessment must be considered as a starting point for system management, so a general flow diagram can be represented in figure (1) for risk assessment.

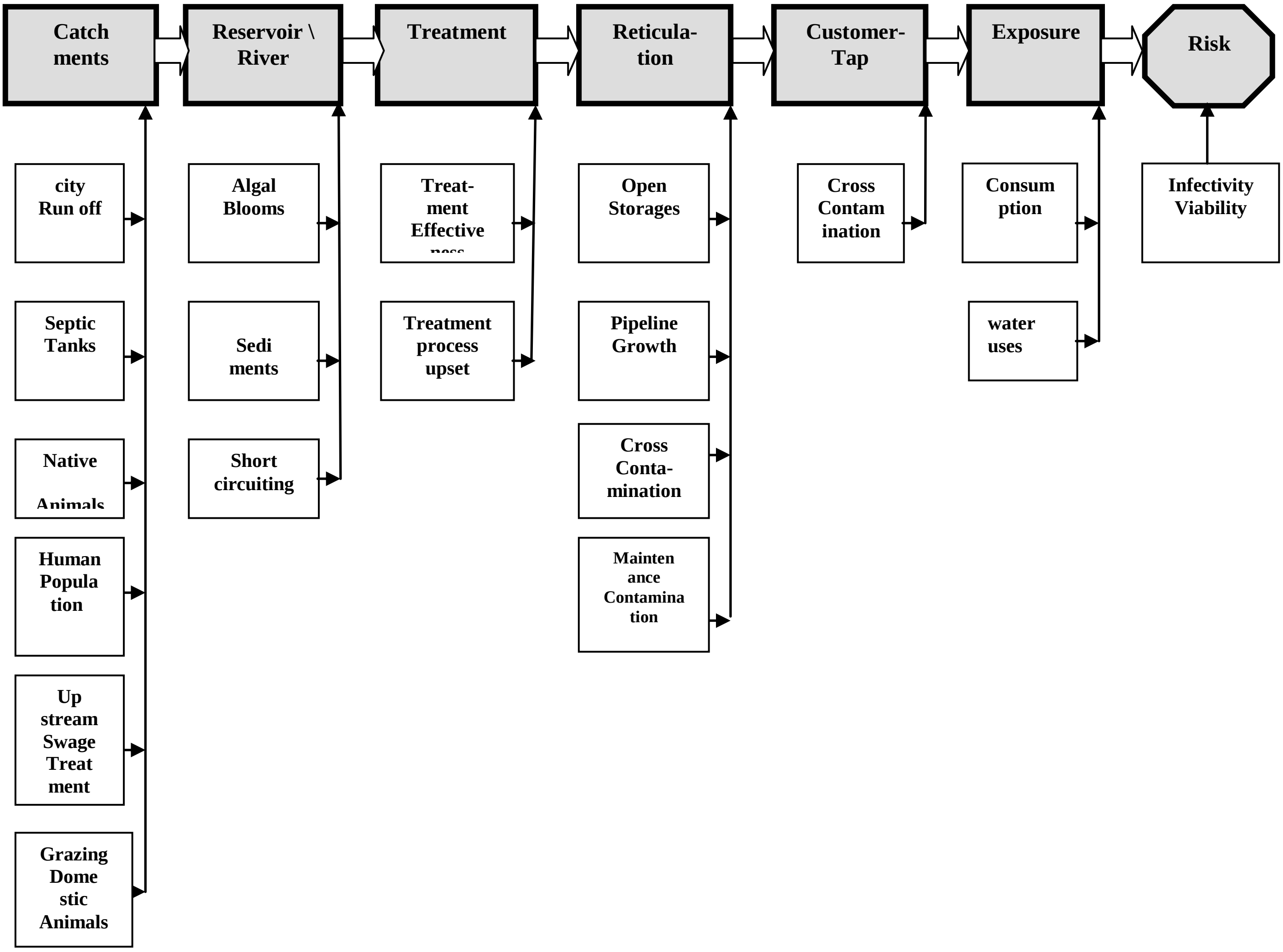

Fig.1 General flow diagram for risk assessment [Stevens *et al*., 1995]

END - PRODUCT TESTING

The traditional approach to water quality management placed a great emphasis on the routine monitoring of water quality. The results of analysis were compared against acceptable concentrations in order to evaluate performance of the water supply and to estimate public health risks (Helmer *et al*., 1999).

The focus of attention was on end-product standards rather ensuring that the water supply was managed properly from catchments to consumer. Although operation and maintenance of water supplies has been recognized as important in improving and maintaining water quality, the primary aim of water suppliers, regulators and public health professionals has been to ensure that the quality of water finally produced met these standards. This reliance on end-product testing has been shown to be ineffective for microbiological quality of water, as evidence has emerged of significant health impact from the consumption of water meeting national standards (Payment *et al*., 1991).

The quality of the source protection measures is an important component in controlling whether pathogens may be present in the final drinking water.

End-product testing has a further weakness in that the number of samples taken is typically very small and not statistically representative of the water produced in a domestic supply. The focus on end-product testing has meant that action is only initiated in response to a failure in relation to the specified water quality standard. However, this typically means that the water has been supplied and may have been consumed before the results of the test are known and the increased risk to health identified. As a result, outbreaks occur and rates of endemic disease remain higher when good practice in relation to water quality management is emphasized. The reliance on end-product testing is therefore not supportive of public health protection and whilst it retains a role in assessing water safety, it should not the sole means by which risks are managed (Davison *et al.*, 2004).

WATER SAFETY PLAN WSP

The objective of the WSP is to supply water of a quality that will allow health-based aims to be met so; the success of the WSP is assessed through drinking-water supply observation including the three key components:

- ***System Assessment*** : Which involves assessing the capability of the drinking-water supply chain (from water source to the point of consumption) to deliver water of a quality that meets the identified targets, and assessing design criteria for new systems;
- ***Detection of Control Measures in a Drinking-Water System***: For each control measure identified, an appropriate means of *operational monitoring* should be defined that will ensure that any deviation from required performance is rapidly detected in a timely manner.
- ***Management Plans****:* Describe actions to be taken during normal operation or extreme and incident conditions, and that document system assessment (including upgrade and improvement), monitoring, communication plans and supporting programs. Figure (2) shows a comparison summery between Historical and WPS approaches to assuring the drinking safety water.

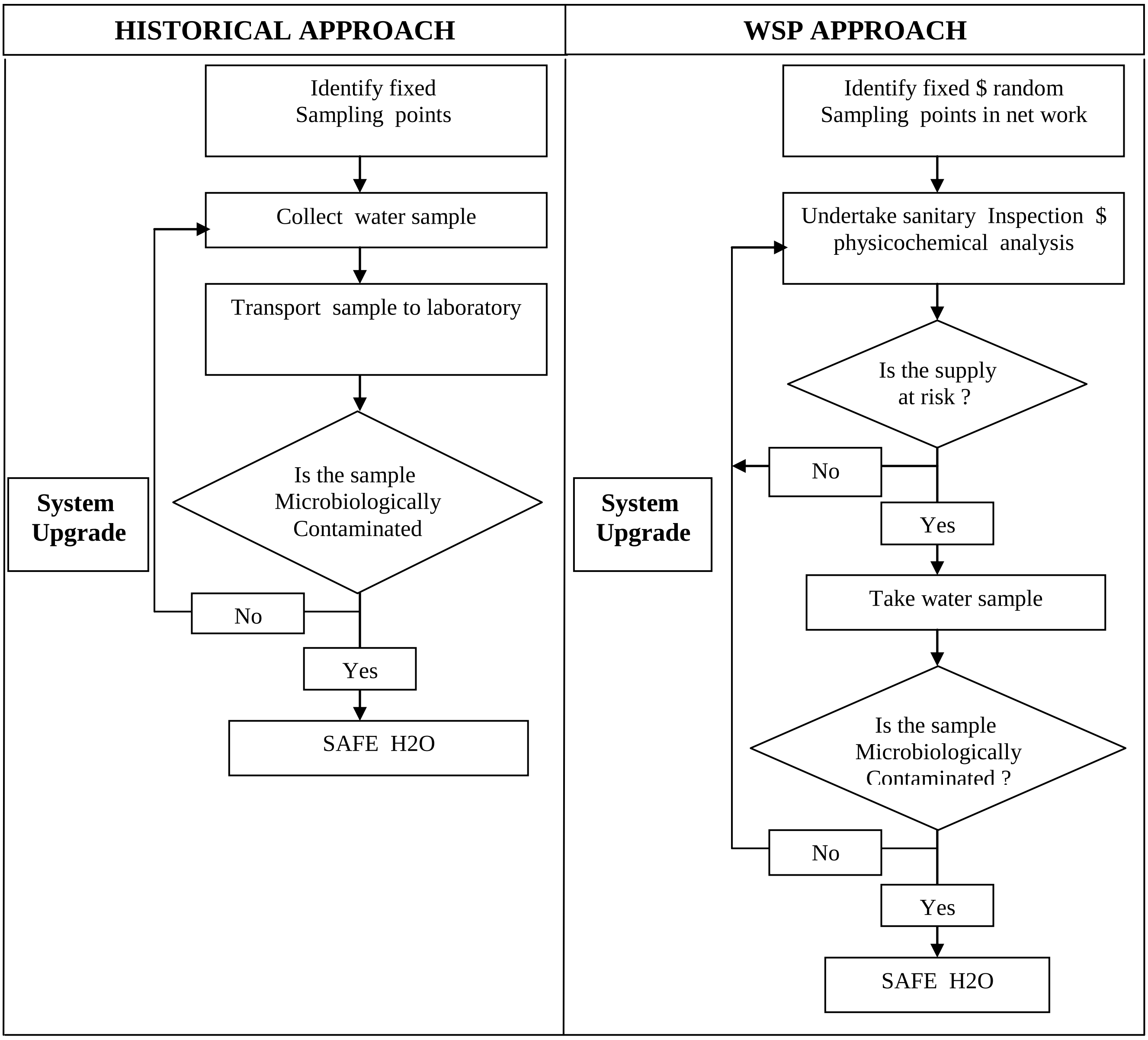

Fig. 2 Summary of approaches to assuring safe drinking water [Tibatemw A, Nabasirye and Godfrey 2003]

PROCEDURE SYNTHESIS FOR WSP DEVELOPMENT

The structure of the methodology in developing and implementing the WSP was represented in three parts: ***Basics***: corresponding to the development phase, in which the basic aspects needed for risk assessment and risk management are described; ***Operational Aspect:***, where, for each element of the water supply step (source, treatment, and distribution), a synthesis of risk management, control measures and corrective actions in *Critical Control Points* CCP are established; ***WSP Practical Application***: where, for operational monitoring and reporting is stated.

BASICS

The assessment of risk and management, from catchments to the customer, constitute the key issues for the whole process. This was made identifying risks and assessing their significance, and stating systematic management of the control measures and corrective actions needed for their control [Vieira, 2004]. So, three working stages can be defined: preliminary tasks (technical inventory of the system); hazards identification and risk assessment; and performance reporting. For each of the working stage, supplementary forms were designed, as described in Table (1).

The WSP approach represent in the principles and steps that have been established in *Hazard Analysis and Critical Control Point* HACCP preventive risk management methodology [Dewettink *et al*., 2001; Nokes & Taylor, 2003]. Figure (3) gives a diagrammatic overview with the key steps for (WSP) development.

Table - 1 Procedure synthesis for WSP development for water system in a station [Vieira, 2004]

Working Stage	Supplementary Forms	Contents
Preliminary Tasks	**Form 1** – Water company general organization.	Flowchart with a summary description of the hierarchical structure and functioning. Includes a brief description of manager tasks and responsibilities for each functional area
	Form 2 – Overview of the water supply system	List and brief description of the main water supply system steps.
	Form 3 – Team constitution for WSP development	Identification of the WSP team: contacts, functions and responsibilities.
	Form 4 – Flux diagram construction and validation.	Construction and validation of the flux diagram from catchments to service reservoirs.
Hazards Identification and Risk Assessment	**Form 5** – Hazards identification and critical control points CCP definition.	Assessment of hazards that can occur in the water supply system. Establishment of CCP.
	Form 6 – Critical limits CL definition and monitoring procedures	Definition of CL. Establishing of monitoring procedures to confirm if CLs are respected
	Form 7 – Corrective actions establishing.	Hazards removal or reduction. For each CCP corrective actions and related procedures have been defined.
	Auxiliary Form 8 – Definition of instructions for CCP control.	Working instructions for CCP control. Upgrade existing or establish new instructions.
Performance Reporting	**Form 9** – WSP compliance.	Instructions for the daily functioning of the WSP (instructions for maintenance and control of CCP). Reports on daily activities and data collected.
	Form 10 –WSP validation and verification.	Assessment of WSP in an annual basis. Analysis of external and internal factors and their influence on system performance.

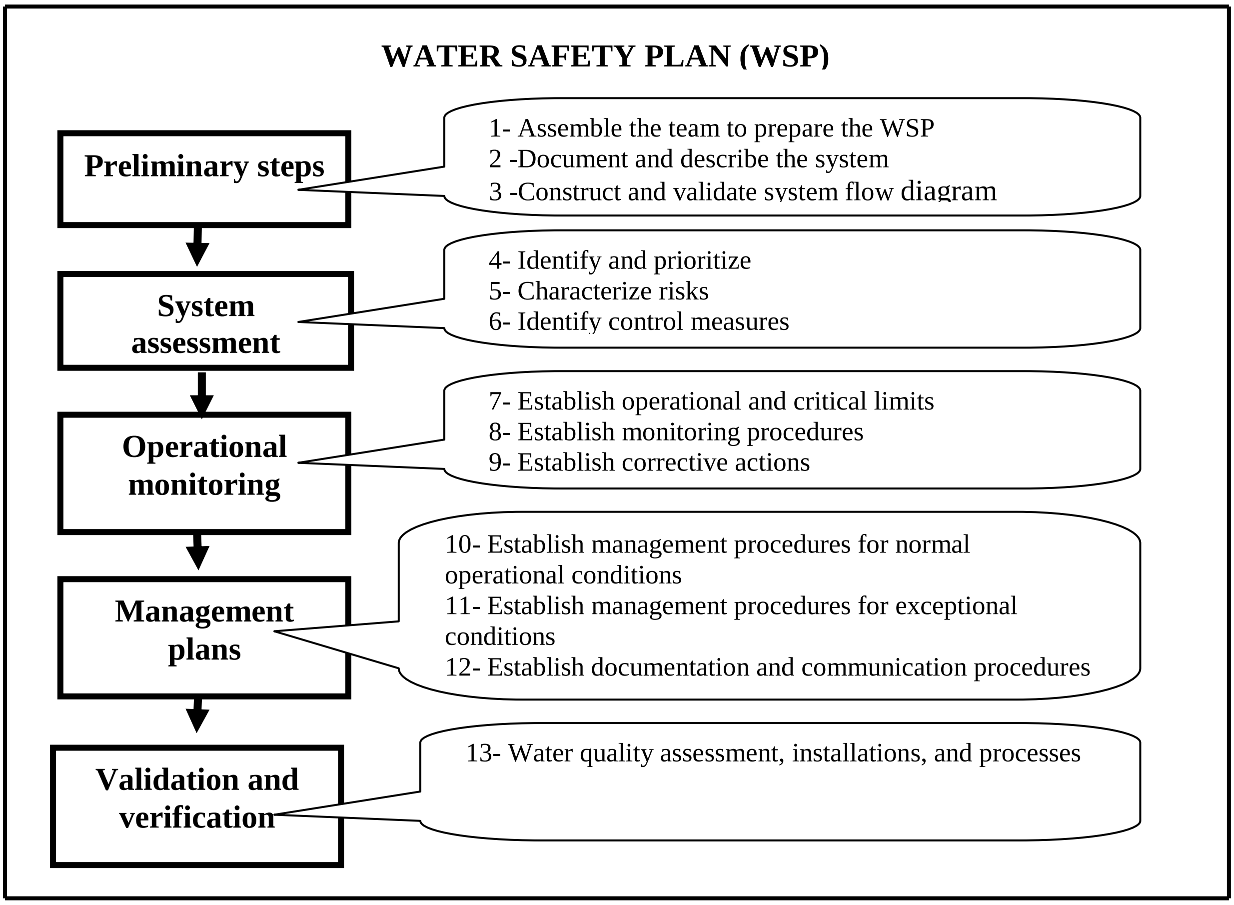

Fig. 3 Overview of the key steps in the development of WSP
[Dewettink *et al*., 2001; Nokes & Taylor, 2003]

WATER SUPPLY SYSTEM IN BAGHDAD

Service water formations of Baghdad responsible for processing water for the city of Baghdad (Baghdad consists of 13 municipalities). The Department of Water Baghdad water processed through the first two systems network processing net water for human consumption and for a second network for the processing of raw water for purposes of watering plants, and the only source of water for the city is the eternal Tigris River. Serving the water area of Baghdad, an estimated 5, 917 square kilometers, including the city of Baghdad and surrounding areas such as (Abu Ghraib and Taji) ..

Situation: We have been tasked with taking a risk assessment for a town of Anywhere *Contaminated Drinking Water System*. The main components of the system consist of two stations and a water storage tank.
(Station No.1) is for example 50 year old that was recently determined to be under the direct influence of supply water with effective filtration. As such, the town had a system installed with duty and standby units.

Additional disinfection is provided by chlorine addition with contact time provided in the water previous to the first user. It is aware that the pumping system for this station is old and has been experiencing frequent breakdowns. A recent inspection of the station has also determined that the casing has some small cracks.

(Station No.2) is a 10 year old with good water. Treatment is provided by chlorination contact time in the section of water main before the first customer. The facilities and equipment for this station are in good working order.

Each station system has chlorine analyzers in place and monitoring equipment to notify the operator (at the site or remotely) on low/high chlorine residual and pumping system failure. The system at (station No.1) is also alarmed. There is no standby power at either station location. The system operates with (station No.2) as the duty. (Station No.1) is usually only brought online during peak demand periods.

However, the town has been noticing that increased usage in the system has required the use of both stations more often. If necessary the water tank in town is capable of providing about a day and a half worth of storage in emergency situations (assuming it is full and there are up normal occurring). Given the problems with (station No.1) and increasing demand, the town has decided to develop the stations in a different setting, however, it is anticipated this process could take a year or more to complete.

SYSTEM ASSESSMENT

The system assessment stage of the WSP development uses the information gained in the system description and hazard analysis and is designed as a first step in determining whether the water supply is able to meet the water quality targets and if not, what investment of human, technical and financial resources would be required to improve the supply. At this stage, specific control measures need not to be defined, but rather the system is looked at in terms of whether it will be possible to define control measures that will allow water safety to be assured.

For example, if the system at (station No.1) a significant not ensured zone, with limited human development over the pumping system and the potential to use legislation to control activities, the system is theoretically capable of meeting established targets and control measures in the catchments can be identified. By contrast, if a supply water from (station No.1) where there is extensive human development and there is no disinfection, the system may not be able to meet the targets without investment at least in a treatment step. The system assessment, therefore, may identify immediate investment requirements essential for meeting the targets and which may become control measures. It is unlikely that all control measures will rely on infrastructure improvements and therefore even in situations when improvements are needed, some control measures can be identified, monitored and managed.

IDENTIFICATION OF HAZARDS AND PREVENTIVE MESURES

The information given by the water supply flow diagram (figure 4) and the deep knowledge of the system performance are the basic conditions for hazards identification and risk assessment. Occurrences of biological, physical and chemical hazards linked with the different steps of the system were investigated.

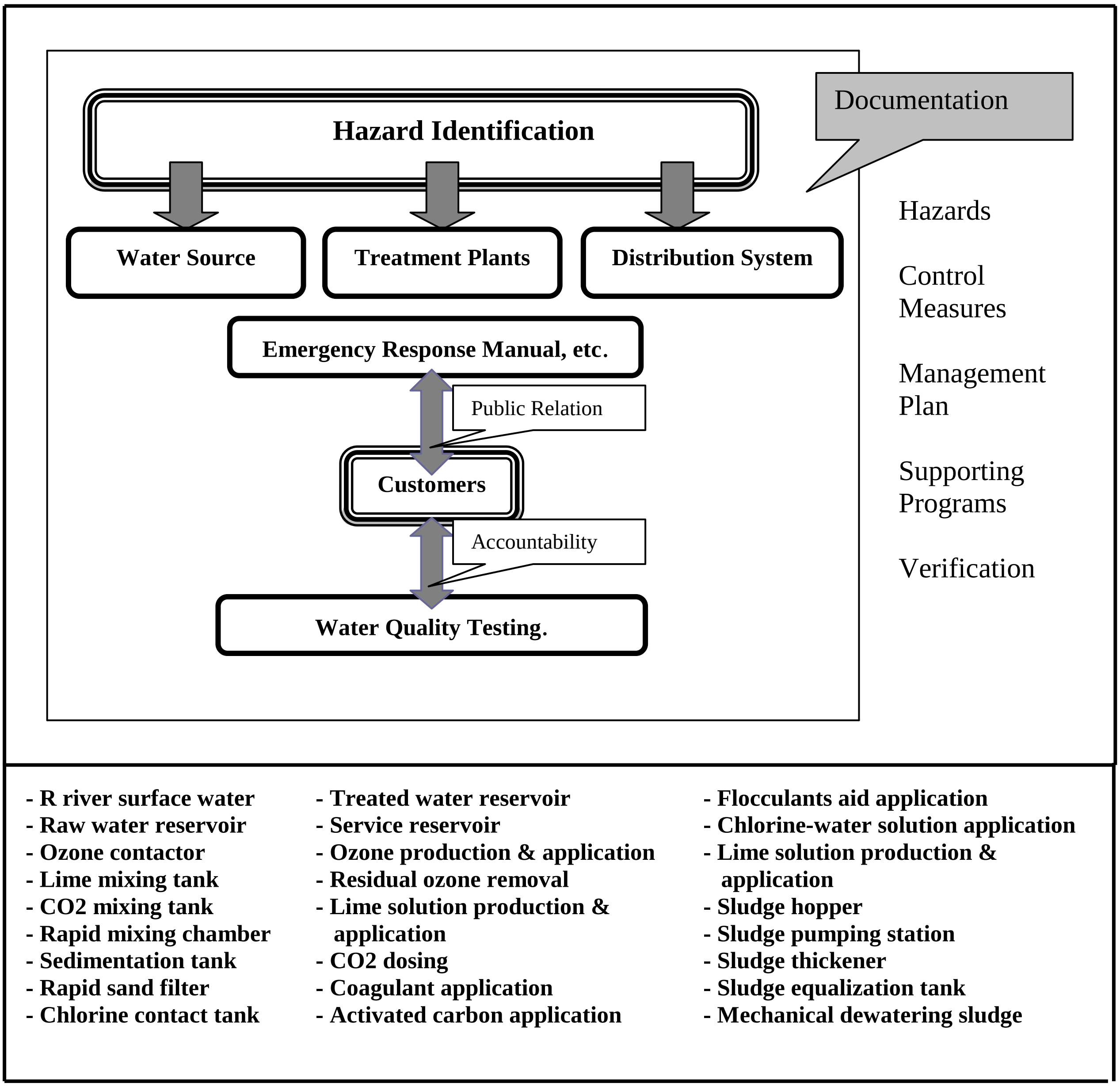

Fig. 4 Flow diagram of the water supply system

PRIORITIZING HAZARDUOS EVENTS FOR CONTROL

The definition of control measures should be based on a ranking of risks associated with each hazard or hazardous event. A risk is the likelihood of identified hazards causing harm in exposed populations in a specified time frame, including the magnitude of that harm and/or the consequences. Those hazardous events with the greatest severity of consequences and highest likelihood of occurrence should receive higher priority than those hazards whose impacts are mild or whose occurrence is very uncommon.

There are a variety of means by which prioritization can be undertaken, but most rely applying expert judgment to a greater or lesser degree. The approach discussed below uses a semi quantitative risk scoring matrix to rank different hazardous events. Within this approach, severity of impact is categorized into three major types of event: lethal (i.e. significant mortality affecting either a small or large population); harmful (i.e. primarily morbidity affecting either a small or large population); and, little or no impact. Table 2 and 3 shows the definition of a set of variables for likelihood/frequency of occurrence and combined severity/extent assessment with appropriate weighting of variables, and Table 4 indicates the final overall score of all possible combinations of the conditions. The approach recognizes that qualitative rather than quantitative information may be all that is available for decision making. However, the qualitative level of relative risk determined based on the likelihood and potential impacts of an event is evaluated using a matrix shown in Table 5, gives an example of that approach for the scenario in a chlorine analyzers for water supply.

The risk analysis model shown in tables is used by the HACCP to calculate the risk factor (i.e. score) for each identified hazard (s) arising from a hazardous event. The risk factor is defined as:

Risk Factor = Severity of Consequences (S) * Likelihood (L)

Table - 2 Risk assessment likelihood or frequency of occurrence scale.

Description	Definition	Weighting
Almost certain	Once per day	**5**
Likely	Once per week	**4**
Moderate	Once per month	**3**
Unlikely	Once per year	**2**
Rare	Once per 5 years	**1**

Table - 3 Risk assessment Severity of consequence or impact scale.

Description	Definition	Weighting
Catastrophic	Potentially lethal to large population	**5**
Major	Potentially lethal to small population	**4**
Moderate	Potentially harmful to large population	**3**
Minor	Potentially lethal to small population	**2**
Insignificant.	No impact or not detectable	**1**

Table – 4 A Simple risk ranking matrix

Likelihood or frequency of occurrence scale		***Severity of Consequences or impact***				
		Catastrophic *Rating: 5*	**Major** *Rating: 4*	**Moderate** *Rating: 3*	**Minor** *Rating: 2*	**Insignificant** *Rating: 1*
	Almost Certain *Rating: 5*	**25 (Very High)**	**20 (Very High)**	**15 (Very High)**	**10 (High)**	**5 (Moderate)**
	likely *Rating: 4*	**20 (Very High)**	**16 (Very High)**	**12 (High)**	**8 (High)**	**4 (Moderate)**
	Moderate *Rating: 3*	**15 (Very High)**	**12 (Very High)**	**9 (High)**	**6 (Moderate)**	**3 (Low)**
	Unlikely *Rating: 2*	**10 (Very High)**	**8 (High)**	**6 (Moderate)**	**4 (Low)**	**2 (Low)**
	Rare *Rating: 1*	**5 (High)**	**4 (High)**	**3 (Moderate)**	**2 (Low)**	**1(Low)**

We can used both a scoring approach as indicated by the numbers in table 4, and others which prefer non-numerical classifications describing the risk (as indicated Low, Moderate, High , and Very High). It should be stressed that when using the scoring approach it is the relative ranking based on the numerical categories rather than the numbers themselves that is important. Furthermore, in applying such approaches common sense is important to prevent obvious discrepancies arising from applying the risk ranking, for instance events that occur very rarely but have catastrophic effects should also be a higher priority for control than those events that have limited impact on health, but occur very frequently.

Table –5 hazardous events identified and assessed for the pumping system

Process Step	Hazardous Event	Hazard Type	Likelihood	Severity	Risk Score
Pumping System	Water pumped during an earthy storm event results in contaminated surface water from catchments that being pumped	Microbes and Chemicals (nutrients and potential pesticides from agricultural practices)	Unlikely (2)	Catastrophic (5)	10
	Cattle grazing near The resource and rain events result in contaminated surface water entering the resource	Microbes and chemicals (mainly nutrients)	Moderate (3)	Catastrophic (5)	15
	The pumped water from the resource causing naturally occurring chemicals for entering water	Chemicals	Rare (1)	Major (4)	4

CONTROL MEASURES

The approach provides a relative measure of potential risk that allows hazards present in a system to be prioritized for evaluation. Filtering was applied to distinguish significant hazards from those considered to be of less significance, and to separate hazards related to aesthetic concerns, which did not result in potable water becoming unsafe to consume. Risks with a risk factor equal to or greater than moderate were classified as significant risks to water quality and were assigned a higher priority for further investigation. Risks with a risk factor less than moderate (i.e. risks with a risk factor score of "low") were classified as risks that did not pose a significant risk to water quality. These hazards were assigned a lower priority for further investigation.

After *Critical Control Points* CCPs identification, *Critical Limits* CL are established based on scientific or operational information. In this case, CLs. have been set according to internal standards, operating procedures, and performance targets of the Quality Management System. Some of the CLs were taken on the safety side of legal standards parameters, in order to guarantee the overall water quality of the system.

The observance of CLs is verified through a wide range of parameters that are monitored with on-site determination. A sampling and laboratory analysis program at different points of the system has also been included. It is expected that the control measures and monitoring activities are effective enough to smoothly control the routine functioning of the system. However, if and when a CL destruction is detected, corrective actions must be considered.

Performance reporting has been established by setting instructions for the daily functioning of the WSP (instructions for maintenance and control of CCP) as well as for the assessment of WSP in an annual basis. Analysis of external and internal factors and their influence on system performance, with special focus on communication, were also included.

As presented in figure (5), a structuring procedure for hazard identification of Treatment Stage and for set up control measures can be proposed for applying , CCPs, CLs and corrective actions.

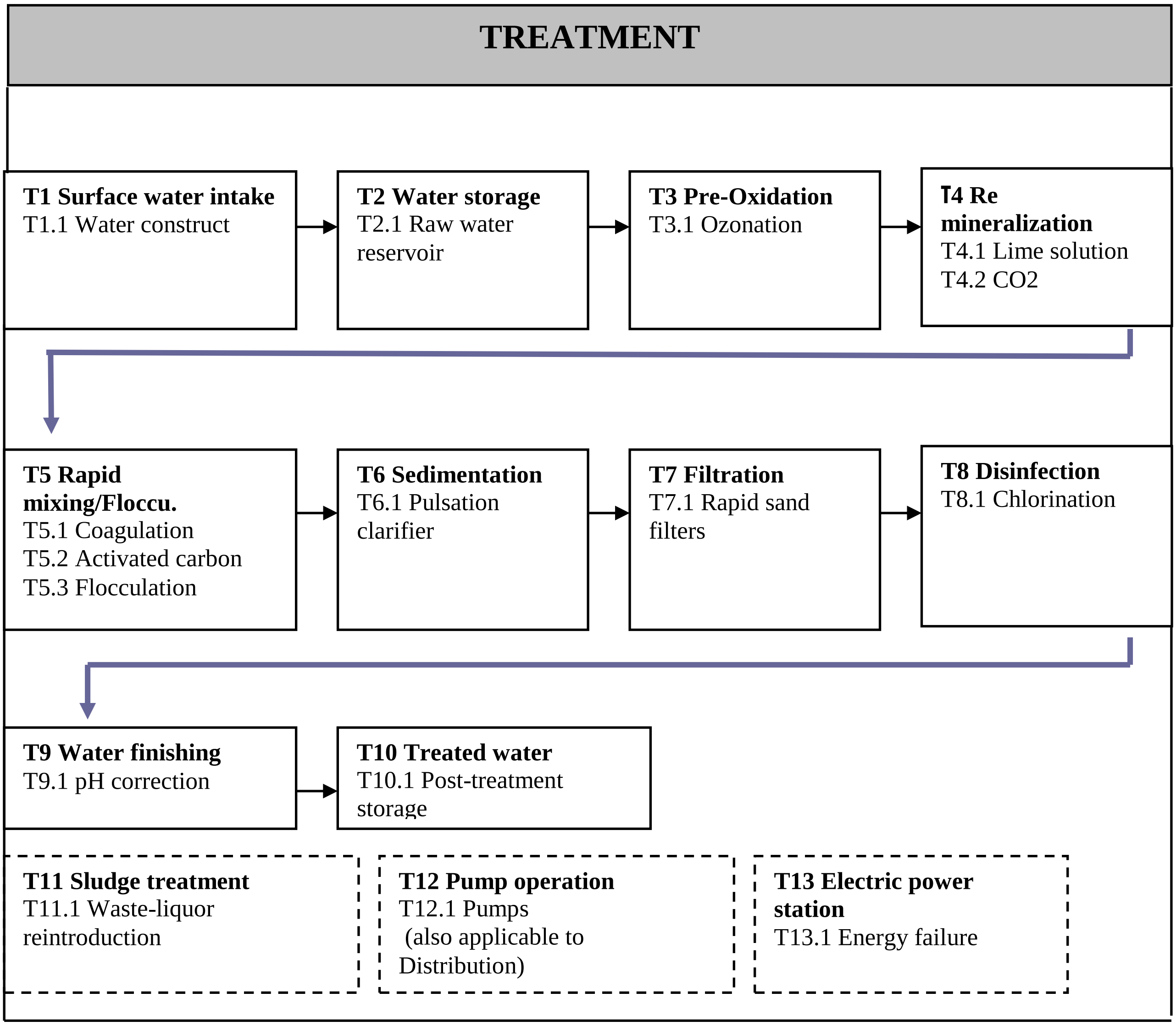

Fig.5 Water supply elements for WSP development

In the development of the (WSP) there were (16) CCPs identified but it is realized that many of the controls initially identified as CCP will not be further considered if the risks are adequately managed with “good management practices” or if effective subsequent control exists. This will be an obligatory point of revision after one year of (WSP) implementation.

OPERATIONAL ASPECTS

For each of the CCPs identified, a synthesis of risk management, control measures and corrective actions was established. As an example of the (Event T7 Filtration) in figure 5, which represent the (10th) CCPs, a designing of operational tables is given in Table 6, where the case of rapid sand filtration is considered. It shows an easy way to understand the major facts associated to this (CCP): particles and organic matter passing through the porous filter media are considered physical and biological hazards; control measures are implemented in order to guarantee the quality of filtered water; corrective actions consist of operational adjustments in previous treatment steps or higher dosing of chlorine at the disinfection step.

Table -6 CCP. Of Event T7 (Example for rapid sand filtration)

EVENT	**T 7.1.1 Filter bed supernatant water out of control**
CCP. 10	**Hazard**: physical and microbiological **Level of risk**: high
Hazard	T7.1.1.1: Organic matter and turbidity not removed
Control measures	Develop a filter analyzer maintenance plan. Adjust the pumping system according to the flow rate to treat. Control backwash water recirculation. Establish an equipment calibration procedure

Operational Monitoring

What?	Unity	CL	Who?	When?	Corrective Actions
Turbidity of treated water	NTU	0.695	A	On – Line	Adjust previous steps in order to optimize filtration efficiency. Higher disinfectant dosing
Color	mg/L Pt-Co	22	B	Weekly	
Clogging optimal point	mm	2350	A	Whenever a criterion is reached	
Filtration time	hour	70			
Residual Aluminum	mg/L Al	0.2	B	Daily	
Ammonia - N	mg/L NH4	0.7			
Cryptosporidium	n.º/100 mL	0	B	Weekly	

WSP PRACTICAL APPLICATION

The secretariat of Baghdad set up a special operations room to follow up (cholera) and take all measures to prevent the arrival in Baghdad and a follow-up laboratory tests on water and the product on a daily basis to ensure its fitness for human consumption and free of any distress pollution.

The results of the examination in all water projects demonstrated the safety net product water from pollutants and fitness for human consumption with an appropriate amount of chlorine disinfectants and to eradicate all kinds of microscopic bacteria and microbes. Table (7) shows the results of laboratory tests of water [2008 ,أمانة بغداد].

After one year of (WSP previous situation) practical application, a series of monthly reports are already available. From them it is possible to have the first understandings of capabilities, vulnerabilities and difficulties for an efficient system management. Figure 6 present example of turbidity removal efficiency by adding the chlorine proportions that mentioned the previous data and the results of laboratory tests of water in the system.

Table – 7 The results of laboratory tests of water[2008 ,أمانة بغداد]

Bacteriological Result	نسبة الكلورين mg / L	المشروع	التاريخ	
صالح للاستهلاك البشري	1.50	مشروع الكرخ/الطارمية	6/12/2008	1
صالح للاستهلاك البشري	1.60	مشروع شرق دجلة/سبع ابكار	6/12/2008	2
صالح للاستهلاك البشري	2.00,2.00,3.70	مشروع الوثبة/باب المعظم	6/12/2008	3
صالح للاستهلاك البشري	4.00,4.00	مشروع الكرامة/العطيفية	6/12/2008	6
صالح للاستهلاك البشري	3.30,2.62	مشروع القادسية/القادسية	6/12/2008	7
صالح للاستهلاك البشري	5.25	مشروع الدورة/الدورة	6/12/2008	8
صالح للاستهلاك البشري	2.00	مشروع الكرخ/الطارمية	7/12/2008	9
صالح للاستهلاك البشري	0.60	مشروع شرق دجلة/سبع ابكار	7/12/2008	10
صالح للاستهلاك البشري	3.42,3.21,3.52	مشروع الوثبة/باب المعظم	7/12/2008	11
صالح للاستهلاك البشري	5.00,4.00	مشروع الكرامة/العطيفية	7/12/2008	12
صالح للاستهلاك البشري	2.80,0.98	مشروع القادسية/القادسية	7/12/2008	13
صالح للاستهلاك البشري	3.00	مشروع الدورة/الدورة	7/12/2008	14
صالح للاستهلاك البشري	5..36,2.47	مشروع الوحدة/المسبح	7/12/2008	15
صالح للاستهلاك البشري	4.06	مشروع الرشيد / معسكر الرشيد	7/12/2008	16
صالح للاستهلاك البشري	2.00	فحص مشترك مع الصحة فقط /مركز صحي بلاط الشهداء	4/12/2008	17
صالح للاستهلاك البشري	3.25-3.50	فحص مشترك مع الصحة فقط /حي الحضر م / ٨٢٤	4/12/2008	18
صالح للاستهلاك البشري	1.50-2.10	فحص مشترك مع الصحة فقط /حي الحضر م / ٨٢٦	4/12/2008	19
صالح للاستهلاك البشري	2.01-2.72	مدينة الصدر م / ٥٢٣	4/12/2008	20
صالح للاستهلاك البشري	1.74-1.93	مدينة الصدر م / ٥٥٣	4/12/2008	21
صالح للاستهلاك البشري	1.73-2.81	مدينة الصدر م / ٥٣٢	4/12/2008	22
صالح للاستهلاك البشري	1.80-2.73	مدينة الصدر م / ٥٢٦	4/12/2008	23
صالح للاستهلاك البشري	1.28-1.54	حي الاورفلي م / ٥٥٥	4/12/2008	24
صالح للاستهلاك البشري	3.10-3.30	حي القادسية م / ٦٠٢	4/12/2008	25
صالح للاستهلاك البشري	2.80-3.00	حي القادسية م / ٦٠٤	4/12/2008	26
صالح للاستهلاك البشري	2.00	حي الكرادة / مستشفى عبد المجيد	4/12/2008	27
صالح للاستهلاك البشري	1.84	حي الكرادة م / ٩٠٩	4/12/2008	28
صالح للاستهلاك البشري	2.07-2.10	حي الكرادة م / ٩٠٥	4/12/2008	29
صالح للاستهلاك البشري	3.74-4.82	حي الكرادة م / ٩٠٧	4/12/2008	30
صالح للاستهلاك البشري	1.50-2.00	فحص مشترك مع الصحة فقط /حي الحرية م / ٤٢٦	4/12/2008	31
صالح للاستهلاك البشري	2.00-2.25	فحص مشترك مع الصحة فقط /حي الحرية م / ٤٢٤	4/12/2008	32
صالح للاستهلاك البشري	2.00-2.25	حي الربيع م / ٣٤٢	4/12/2008	33
صالح للاستهلاك البشري	2.00	حي الربيع م / ٣٤٠	4/12/2008	34
صالح للاستهلاك البشري	2.25	حي الربيع م /٣٣٨	4/12/2008	35
صالح للاستهلاك البشري	2.25	حي الربيع م /٣٣٢	4/12/2008	36

Process	Efficiency of Filtration% 04/12/2008	Efficiency of Filtration% 07/12/2008
Raw Water	0	0
Sedimentation	67.08	97.5
Filtration	100	98.33
Treated Water	95.65	98.33

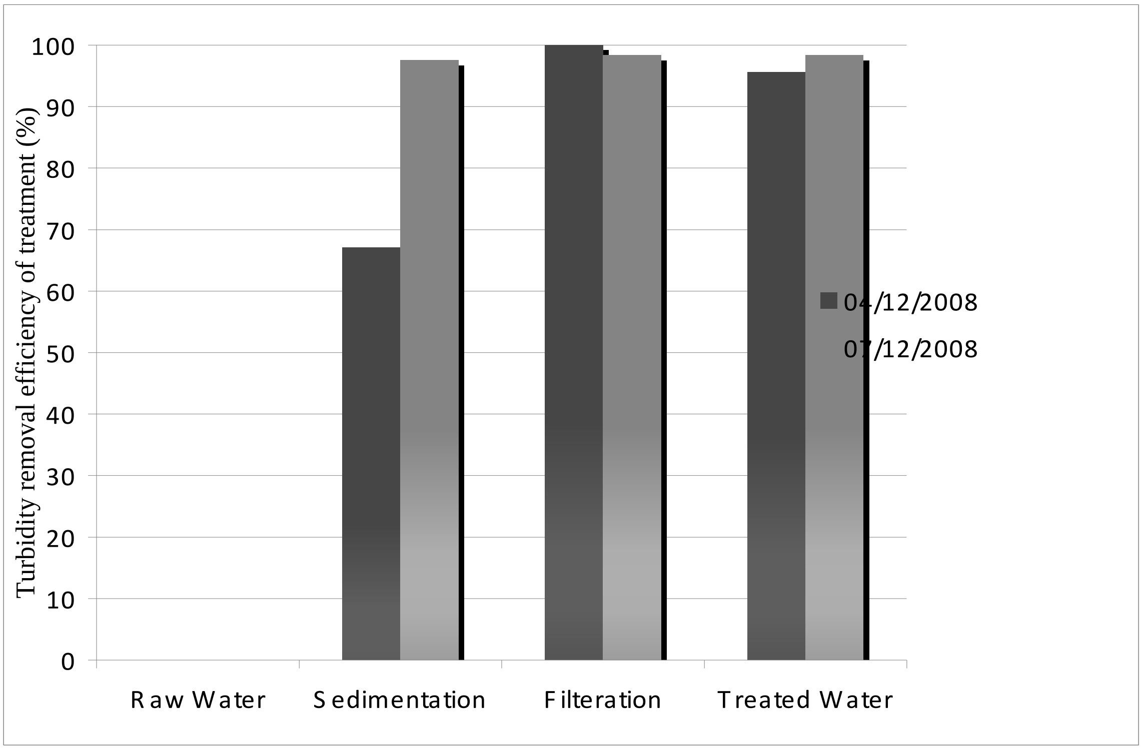

Fig. 6 Turbidity removal efficiency through the water supply system

CONCLUSIONS

WSP is a process control oriented management system that can help water suppliers to produce and deliver good and safe drinking-water, contributing in this way to improve public health protection.

Development and implementation of a WSP in The Department of Water Baghdad water, have also demonstrated that water suppliers can successfully adopt methodologies for risk assessment and risk management in drinking-water systems. This water company has already quality management systems according to ISO standards (for water quality monitoring, and for preventive maintenance of the water system). Performance reporting has been established by setting instructions for the daily functioning of the WSP (instructions for maintenance and control of CCP) as well as for the assessment of WSP in an annual basis.

Analysis of external and internal factors and their influence on system performance, with special focus on communication, were also included.

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NOMENCLATURES

Symbol	Description
CCPs	Critical Control Points
CLs	Critical Limits
HACCP	Hazard Analysis and Critical Control Points
L	Likelihood
QC	Quality Control
S	Severity
WSP	Water Safety Plan