Uva Wellassa University of Sri Lanka
Faculty of Science and Technology
Department of Science and Technology
300 Level 2nd Semester Examination – December 2018/January 2019
MRT 381-2 Water Safety Plan

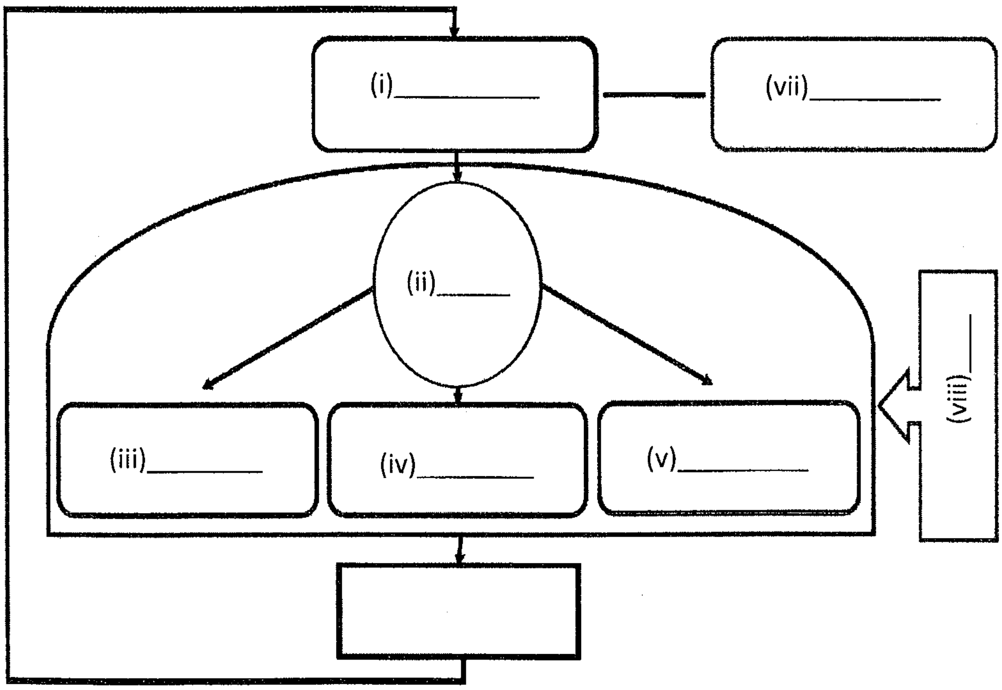
Uva Wellassa University

Instructions
Duration: 02 hours
Number of questions: 06
Number of questions to be answered: 06
Mark allocation: 100
Illustrate your answers with sketches/diagrams where necessary.
Return the question paper

Index Number:-

1.

a. Complete the following diagram on framework for safe drinking water. (2 marks)



b. Explain Water Safety Plan approach. (5 marks)

c. Describe prerequisites for developing a Water Safety Plan. (6 marks)

d. What are the limitations of relying on water quality testing alone? Explain them. (7 marks)

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Question 2, 3, 4, 5 and 6 are based on following case study.

The following case study is on the Water Safety Plan (WSP) implementation in two rural areas in Beijing, China

"The access to safe tap water in Beijing rural areas is a top priority in China. The investigating drinking water safety in rural Beijing provides a perfect model for investigating rural drinking water safety in other areas of China. Thus, two typical water utilities (Plant A and Plant B) in rural Beijing were selected to study the application of WSP management tools. The WSP for this study was developed following the WHO guidelines. Table 1 shows the information for selected water utilities.

Table 1: Water supplier information for two selected water utilities

	Plant A	**Plant B**
Region	South of Beijing	North of Beijing
Ownership	Public	Public
Water Source	Groundwater	Groundwater
No. Consumers	45,000	10,000
Water Treatment Process	Aeration, filtration and chlorination	Aeration, filtration and chlorination

Appropriate implementation of WSP offers an important opportunity to engage in and promote preventative risk management within water utilities. To ensure success, the whole organization, especially organizational culture and leadership in WSP implementation are crucial. The WSP team members for this study consisted of the management and technical staff of Beijing Municipal Bureau of Health, Beijing Water Group Company, and water utility staff.

The description of water systems was carried out by the examination of basic materials and on-site inspection. Basic materials included the frame chart for water utility management, components of water treatment systems (intake information, water treatment process, storage tanks, and water distribution networks, etc.), the rule and regulation of water utilities, emergency reserve, staff training, power and water process device management, user complaints and customer satisfaction surveys. On-site inspection included item-by-item audits of the water supply system.

The process diagram of the water treatment is shown in Figure 1. Risk factors for water supply system were identified according to the WHO water safety plan guidelines and the evaluation form of the risk factors of the water supply facilities in rural areas. Risk factors for this study included water sources, water treatment processes, water distribution networks, water consumers, and other relevant supporting elements.

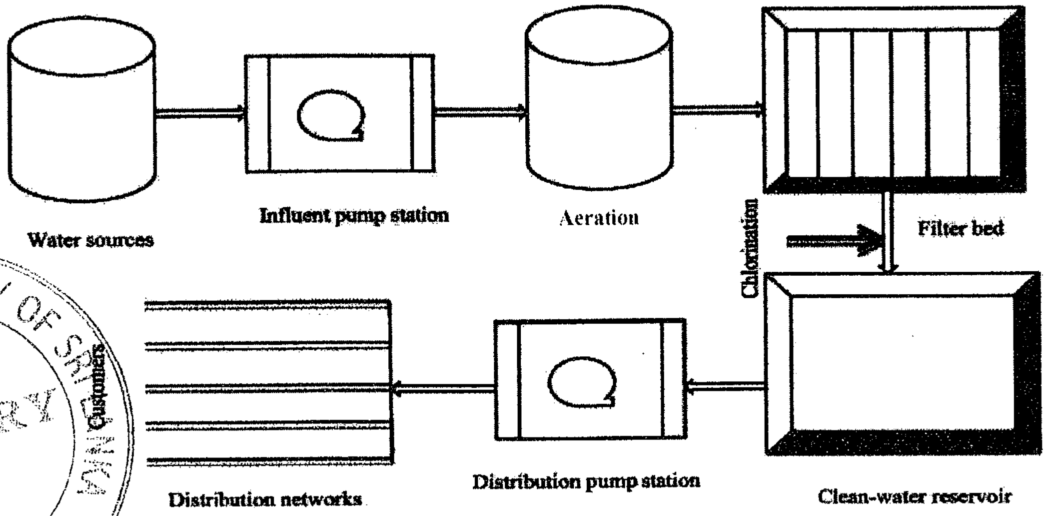

Figure 1: Process diagram of water treatment

A semi-quantitative risk matrix approach was used to conduct the water supply system risk assessment (Table 2). The risk levels were divided into: very high (>15), high (10–15), medium (6–9), low (<6).

Table 2: Semi-quantitative matrix approach

Likelihood	Rating	Consequence	Rating
Almost Certain/Once a day	5	Insignificant/No impact	1
Likely/Once a week	4	Minor impact	2
Moderate/Once a month	3	Moderate impact	3
Unlikely/Once a year	2	Major regulatory impact	4
Rare/Once every five years	1	Catastrophic public health impact	5

All risks should be documented in the WSP and be subject to regular review even when the likelihood is rare and the risk rating is low. Based on the water safety plan manual requirements, all potential hazards were considered and those that constituted a significant risk to drinking water quality were established. How each of these risks was controlled and whether the controls were adequate were considered too. Daily or weekly checks were carried out to make sure that the operator was following the operating procedures. The existing control measures, risk assessment, and risk optimization were recorded and reassessed for their effectiveness.

The water system assessment for Plant A revealed that there was an agricultural fertilization surrounding its water source. Also, livestock farming was on going in proximity to the water source which in turn leading to livestock defecation around water source. It was found that the staff of the water treatment plant was unable to control the amount of disinfection dosing. Apart from that, it was also found that they had been practicing wrong analytical method for checking chlorine dioxide and no water quality testing after cleaning or maintenance of tank and pipes. This had led to further worsen the situation. The assessment indeed assisted in revealing that there were no safety measures on storage of disinfectants and no effective management methods for disinfection materials as well. Also, they did not have an emergency plan prepared for the entire water system. For Plant B, on the other hand revealed that there was no fence surrounding the water source. Similar to Plant A, agricultural fertilization surrounding the water source was common issue for Plant B also. It further revealed that disinfection unit was out of order and the mandatory laboratory testing were not being conducted by the staff. There was no water quality testing after cleaning or maintenance of tank and pipes, no safety measures on storage of disinfectants, no effective management methods for disinfection materials and no emergency plan for Plant B as similar to Plant A. In addition, it was identified that staff training was not perfect in Plant B.

In order to address the issues identified above, the controls were made as follows for the Plant A. Signing an agreement with the village committee for not permitting an agricultural fertilization surrounding water source; Strengthening the monitoring of relevant indicators of the source water; Placing warning signboards for banning the livestock defecation; Improving health of water source surrounding; Establish the disinfection instructions and correct operation method; Establish systems of chlorine dioxide monitoring methods and establish procedures of staff training; Establish a system to provide testing records and reports; Establish management system and standardization for disinfection material; Develop provisions of the safety security measures on storage disinfection and Establish contingency plans. For Plant B, controls were made as fencing and adding the warning signboard; Sign an agreement with the village committee for not permitting agricultural fertilization surrounding water source; Strengthening the monitoring of relevant indicators of the source water; Reinstalling and commissioning of disinfection equipment and establishing operating procedures and personnel training; Establishing operating procedures and personnel training for laboratory technology; Establishing system to provide testing records and reports; Establishing a management system and standardize the treasury and Establishing contingency plans Staff training, inspection personnel training (content: the written and practical operation of blind assessment).

Records of regular monitoring and verification were maintained in both electronic format and hard copies. Record forms were developed for incident investigations, water utility water safety staff, monitoring of checking the controls, repair and maintenance, and verification. Staff training is an important part of the WSP implementation. The staffs of water utilities were trained on site. The training program included knowledge of laws and regulations, and knowledge of water treatment processes and pollution detection methods. After training, participating staff were tested on their theoretical knowledge of the water system. In addition, to ensure the accuracy of the drinking water monitoring results, technical training content of the water quality laboratory technicians was strengthened.

Laboratory sampling and analysis were conducted to verify controls were working accurately. These included microbiological and chemical sampling and quality assurance and quality control analysis.

Nine water quality indicators were selected for verification. Total (bacterial) coliform counts, the microbiological indicator parameter, were checked weekly. Chemical indicator parameters – color, turbidity, iron, manganese, and free chlorine – were checked daily. Nitrate nitrogen and nitrite nitrogen, toxicological parameters, were checked weekly. The water quality of Plant A and Plant B before implementation of WSP and the changes of water quality after WSP in Plant A and Plant B are listed in Table 3. Customer satisfaction surveys were also carried out to verify the effect of WSP. The customer satisfaction for water supply pressure, water quality, and the overall satisfaction for Plant A and Plant B are shown in Table 4.

Table 3: Water quality of Plant A and Plant B before and after WSP

Parameter	Plant A		Plant B	
	Before WSP	*After WSP*	*Before WSP*	*After WSP*
	Compliance percentage	Compliance percentage	Compliance percentage	Compliance percentage
Color	99.45	100.00	99.44	100.00
Turbidity	95.10	100.00	94.44	100.00
Fe (mg/kg)	99.44	100.00	99.44	100.00
Mn (mg/kg)	99.45	100.00	99.44	100.00
NO_2^- (mg/kg)	100.00	100.00	100.00	100.00
NO_3^- (mg/kg)	88.24	100.00	89.41	100.00
Total bacterial count (cfu/ml)	91.46	100.00	89.89	100.00
Total coliform (cfu/100ml)	93.90	100.00	95.12	100.00
Free chlorine (mg/kg)	89.02	100.00	91.25	100.00

Table 4: Results of customer satisfaction surveys of Plant A and Plant B

		Total population	Excellent (%)	Good (%)	Bad (%)
Plant A	Water supply pressure	120	91.7	6.7	1.6
	Water quality	120	85.9	13.3	0.8
	Overall satisfaction	120	95.8	4.2	0.0
Plant B	Water supply pressure	53	18.8	75.5	5.7
	Water quality	53	24.5	73.6	1.9
	Overall satisfaction	53	79.2	20.8	0.0

Management plans describe actions to be taken during normal operation or extreme and incident conditions. The emergency plans were developed and improved for each water utility of Plant A and Plant B. Water emergencies include water pollution, emergency power outages, and sudden damage of water supply pipes."

2.

a. Write down main stages in developing a WSP in order. (5 marks)

b. Explain to what extent the first stage of developing a WSP is fulfilled the guidelines given in WHO manual in relation to the given case for both Plant A and Plant B. (7 marks)

c. What are the less fulfilled steps in first stage of developing a WSP in relation to the given case for both Plant A and Plant B, if any. (8 marks)

3. Perform complete risk assessment of the WSP using semi-quantitative matrix approach separately for Plant A and Plant B. (20 marks)

(The identified hazardous events and hazard type should also be included and the justification to the rating used)

4.

a. What is the definition of control measures? (4 marks)

b. What are the respective control measures taken for each hazardous event mentioned in the case separately for Plant A and Plant B? (12 marks)

c. Explain the importance of validation of control measures (4 marks)

5.

a. What is the definition of operational monitoring? (2 marks)

b. What is the main objective of verifying the effectiveness of WSP? (3 marks)

c. In relation to the given case, explain in which ways the effectiveness of WSP is verified for both Plant A and Plant B. (5 marks)

6.

a. What would be the reason(s) to the increment of compliance percentages of each parameter shown in Table 3? (5 marks)

b. Describe the value of management plan (or the documentation) and the importance of emergency plan in relation to the given case. (5 marks)