SECM/15/031

Comprehensive Risk Assessment and Risk Management is Effective Tool of Consistently Ensuring the Safe Drinking Water in Colombo Metropolitan Area and Their Suburbs

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Abstract: Colombo is the largest economic and tourist attractive city in Sri Lanka, situated geographically at 127 degree 30' E longitude and 37 degree 00' N latitude. The city is spread over 37.3 km2 and its present population is 5.6 million in Colombo district .City administration is governed by Colombo Municipal Council with sub units in suburbs of Colombo.

The drinking water supply is managed by the National Water Supply & Drainage Board (NWS&DB). It's responsible for operating water treatment plants, safe storage and distribution of drinking water to consumers.

Quality of the drinking water is customer satisfaction, therefore to ensure the customer satisfaction, not only the treated water quality – SLS 614: 2013 – but also raw water quality has to be monitored within SLS 722: 1985.KelaniRiver is the main drinking water source for 80 % population from Colombo and this river provides 700,000 m3 /day raw water to the water treatment plants in Ambatale and Biyagama.

NWS&DB continue monitoring the raw water quality of Kelani river taking samples of selected locations to test selected water quality parameters.The purpose of testing the water quality in production centres and distribution system is to supply good quality drinking water achieving economic development with a healthy nation. Therefore NWS&DB has laboratory network in Colombo district to test physical, chemical and microbiological parameters in potable water according to SLS 614: 2013. Around 600 numbers of samples are taken monthly from distribution system to ensure microbiological quality of the drinking water.

Water quality monitoring is reactive attitude rather than preventive,field investigation revealed that any action and activity that is required to prevent or eliminate hazards.Therefore risk assessment, risk management and control measures are required to ensure the quality of drinking water to achieve health base targets..

Keywords: Control Measures, Hazards, Risk Assessment, Risk management

1. Introduction

Safe drinking water is a fundamental requirement and internationally accepted human right. The present approach for achieving safety of water is end product testing. This is to test water intake, after treatment at the water treatment plant, within the distribution system and at the consumers point. This traditional method has the shortcomings in a water supply system such as too little results and too late for preventive action and traditional method is reactive rather than preventive. The Water Safety Plan approach provides a management tool for improving safety of water and adopting multiple barriers risk management approaches using control measures. The final outcome is continuous safety and quality assurance of drinking water.

Colombo is the largest economic and tourist attractive city in Sri Lanka, the city is spread over 37.3 km2 and its present population is 5.6 million in Colombo district . The drinking water supply is managed by the National Water Supply & Drainage Board (NWS&DB). It's responsible for operating water treatment plants, safe storage and distribution of drinking water to consumers. Kelani river is the main drinking water source for 80% population in Colombo and the river provides 700,000 m3 / day raw water to the water treatment plants in Ambatale and Biyagama..

2. Hypothesis

2.1 Water Quality Monitoring

In order to maintain the raw water quality within the SLS 722: 1985 limits regular monitoring of water quality is carried out by NWSDB and Central Environmental Authority (CEA). As Kelani river is the main drinking water source for 80 % population from Colombo, NWSDB and CEA continue monitoring the water quality of Kelani river since 2003 taking samples of selected locations as elaborated table 1.

Table 1: Regular sampling locations of Kelani River Basin by NWSDB and CEA

Sampling Location NWS&DB under Pavithra Ganga programme	Sampling Location CEA under Pavithra Ganga programme
Victoria bridge	Japanese friendship bridge
RaggahawatteEla (Tributeriey)	RaggahawatteEla (Tributeriey)
MahaEla (Tributeriey)	MahaEla (Tributeriey)
PusseliOya (Tributeriey)	PusseliOya (Tributeriey)
Hanwella Bridge	Hanwella Bridge
PugodaEla (Tributeriey)	PugodaEla (Tributeriey)
Pugoda Ferry	Pugoda Ferry
WakOya (Tributeriey)	WakOya (Tributeriey)
Seethawake Ferry	Seethawake Ferry
Thalduwa Bridge	Thalduwa Bridge
Kaduwela bridge	Kaduwela bridge
Welivita	Welivita
Ambatale Intake	

Given below the water quality parameters tested by CEA and NWSDB monthly basis.
pH, Electrical Conductivity, Turbidity, Temperature
Dissolved Oxygen
Chemical Oxygen Demand
Biochemical Oxygen Demand
Phosphate, Nitrate, Chloride
Dissolved Lead and dissolved Chromium
Microbiological parameter such as Total Coliform and Feacal Coliform (E.coli)
Heavy metals Pb and Cr.
In addition, places where industrial zones discharges waste water such as downstream canal from Seethawaka Industrial Zone" and "Biyagama Industrial Zone" effluent discharge is checked by NWSDB.
Seetawaka – pH, Dissolve Oxygen (DO), colour on daily basis and Total Suspended Solid (TSS), Biochemical Oxygen Demand (BOD) & Chemical Oxygen Demand (COD) weekly basis.
Biyagama – TSS, BOD, COD &pH.monthly basis
Existing mechanism for monitoring Kelaniriver can be further strengthened ensuring maintaining the raw water quality SLS 722:1985 limits by restoring places where the water quality is deteriorated identified bywater quality monitoring. Less than 300 words abstract should be provided as indicated.

2.2 Water quality monitoring in Water intakes

The purpose of testing the water quality in two intakes is to supply good quality drinking water achieving economic development with a healthy nation. Water we drink must satisfy criteria such as free from pathogens, injurious chemical and must be aesthetically satisfactory. Therefore NWSDB tests for Physical, microbiological and Chemical parameters in treated/potable water according to SLS 614: 2013 Ambathale and Biyagama are the main two water treatment plants in the Kelani river with capacities of 540,000 m^3/day and 180,00m^3/day respectively. Water quality testing of Kelaniriver in mentioned two intakes is carried out by the NWSDB laboratories on daily basis to ensure providing safe drinking water to more than 1 million people in the country.

At present Biyagama and Ambathale water treatment plants have online analysis of water quality parameters such as pH, turbidity, Dissolved Oxygen, Residual Chlorine (RCl), Aluminiumcolour and conductivity. Apart from that selected physical and chemical parameters were monitored hourly basis by the process control laboratories in our water treatment plant.

2.3 Random water quality monitoring by NWSDB

Four laboratories such as Kadawatha, Rathmalana(Western South), Ambathale and Kalatuwawa laboratories are dedicated to monitor water quality of the distribution network on the basis of population served.

Ambatale Laboratory samples/month	200
Kalatuwawa Laboratory samples/month	50
Western South Lab (Ratmalana) samples /month	80
Western North Lab (Kadawatha) samples/month	80

Apart from that heavy metal – Lead (Pb), Cadmium (Cd), Chromium (Cr) and Arsenic (As) analysis were carried out in our clear water reservoirs four times per month for Ambatale and the other places once in a month. Heavy metal contamination is checked in distribution system to ensure the quality of drinking water. Past analytical

reports revealed that the heavy metals were not detected or below the detection limits in drinking water.

Monitoring is not the only tool to assure the safety of drinking water but also identification of hazards and assesses risks from catchment to consumer and prioritizes the risk and focuses on management those hazardous events within the highest risk and manage the risks by using control measures are very important to provide safe drinking water.

3. Methodology

Hazards and hazardous events are identified through visual observations, water sampling and testing and previous studies that are evaluated throughout the water supply systems. Possible hazards are identified from catchment to consumer and analyzed the variation of water quality parameters throughout the water supply system. These identified hazards are evaluated as low, medium and high risks using semi quantitative matrix and the same time possible control measures are implemented.

Table 2: Risk Assessment Table

Likelihood	Public health	Severity				
		Impact on public health	Major regulatory impact	Moderate aesthetic impact	Minor compliance impact	No impact or not detect
		5	4	3	2	1
Once per day or more	5	E	E	VH	H	M
Once per week	4	E	VH	H	M	L
Once per month	3	VH	H	M	M	L
Once per year	2	H	M	M	M	L
Once every 5 years or less	1	M	L	L	L	L

4. Results

All identified hazardous events are mapped in the catchment of the Kelani river and same time industries are categorized as type A, B and C. The type A industries are high polluting industries will not be permitted to be located upstream of drinking water abstraction point. The effluents from type A industries should not be discharged upstream directly or indirectly. The effluents from these industries should be treated to the designated national effluent standards and discharged to water bodies, which are not used as drinking water source or downstream of the last drinking water abstraction point or to the marine environment. Type B industries will be permitted to be located upstream of drinking water abstraction point. Industries and their distribution in Kelani river basin are given below.

Table 03: Industries in Kelani river bas

District	DSD	A	B	C	Total
Colombo	Homagama	213	205	311	729
	Hanwella	72	193	111	376
	Colombo	138	84	15	237
	Kolonnawa	87	59	90	236
	Kaduwela	268	255	136	659
	Thibirigasyaya	51	41	3	95
	Kotte	45	63	3	111
	Maharagama	77	85	111	273
	Padukka	111	82	131	324
	Kesbewa	113	139	331	583
Gampaha	Mahara	79	132	110	321
	Wattala	131	53	55	239
	Biyagama	116	130	178	424
	Dompe	94	73	129	296
	Kelaniya	83	50	75	208
	Ja- Ela	163	104	63	330
	Gampola	86	79	121	286
	Attanagalla	70	103	21	194
Kegalle	Ruwanwella	53	80	73	206
	Dehiovita	35	41	74	150
	Yatiyantota	31	29	42	102
	Deraniyagala	15	20	15	50
	Warakapola	54	70	105	229
	Galigamuwa	44	52	104	200
	Aranayaka	16	49	52	117
	Bulathkohupitiya	11	26	24	61
	Kegalle	47	70	114	231
Ratnapura	Eheliyagoda	31	49	84	164
	Kuruwita	49	51	137	237
	Ibulpe	17	32	113	162
	Ratnapura	30	53	117	200
NuwraEliya	Ambagamuwa	37	14	113	164
	NuwraEliya	61	13	59	133
Kandy	Gaga IhalaKorale	15	14	41	70
	PasbageKorale	25	27	23	75
Grand Total		2705	2827	3473	9005

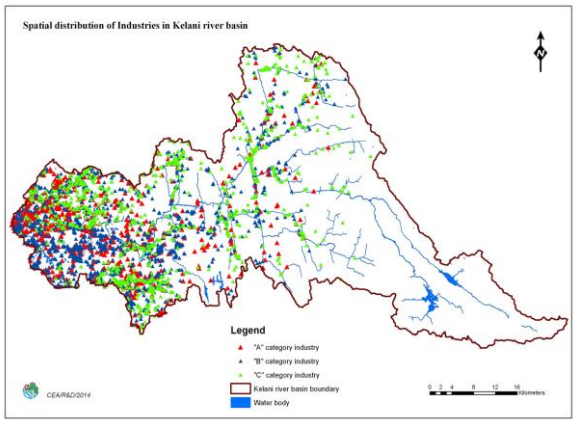

Figure 1: Distribution of type A, B and C industries in Kelani river basin

Table 4: Hazard Analysis

Process Step	Hazard	Hazardous Event	Risk Band	Control Measures	Risk Band
Kelani river catchment	Chemical	Oil & Grease contamination through Pattiwila canal	Medium	No current control measure / Propose to construct Wetland	Medium
Kelani river catchment	Microbiological	Contamination through storm water runoff during monsoon	High	No current control measure	High
Kelani river catchment	Physical, Chemical and Microbiological	Industrial wastewater discharge from two main industrial zones	High	Improvement of the existing treatment plants and interceptor sewerage line	High
Secondary Chlorination in Maharagama	Microbiological	Under dosing / No proper dosing system	Very High	Installation of new chlorinator	Medium
Clear water reservoir in Church Hill	Microbiological	Contamination through air vent	Medium	Fix the suitable mesh for the air vent	Low
Distribution system in Elvitigala Flats	Microbiological	Cross contamination with sewerage line	Very High	Replacing the pipeline	Low
Fecal contamination in Mattegoda distribution system	Microbiological	Stagnation of water	Very High	Installation and proper operation of the washout	Medium

5. Conclusion

Water quality monitoring and water quality surveillances are required to conform the product is to fit for human consumption but comprehensive risk assessment and risk management is required to assure the safety of the drinking water. Control measures are placed at each process step for each hazardous event. These control measures taken to prevent further contamination, removing hazards or inactivating the pathogens and monitoring the quality of water during distribution.

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