STUDY OF WATER QUALITY OF SYLHET CITY AND ITS RESTAURANTS: HEALTH ASSOCIATED RISK ASSESSMENT

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Received 13 July 2005; revised 20 August 2005; accepted 25 November 2005

ABSTRACT

A study of the water quality conditions of Sylhet city of Bangladesh and its restaurants was carried out to assess risks to human health. The investigation was based on questionnaire survey of restaurants and laboratory tests on water samples obtained from the restaurants, tube wells of the city and Surma River the two main sources of water supply to the city. The test parameters were dissolved oxygen; conductance, hardness, pH, temperature, turbidity, essential and trace elements, dissolved and suspended solids and coliform bacteria. The quality of sanitary facilities and handling of food in the restaurants were also examined. It was found that the drinking water of each restaurant was contaminated with fecal coliforms and 25% restaurants had unsafe levels of iron in the water supply. Improper solid waste dumping was found as one of the reasons of groundwater pollution. Statistical analysis based on Pearson's correlation coefficient revealed significant correlation between the extent of groundwater pollution and dumping of solid waste effluents in the immediate vicinity of ground water (tube wells). It was observed that 75.69% (coefficient of determination r^2= 0.7569) variation in the value of groundwater near the dumping place showed association with variation in the value of water quality within the dumping place. Health risk score for coliform bacteria was 1,474.77, indicating high risk. The results of the study help in enhancing awareness of health hazards of contaminated food among the consumers as well as in drawing attention of health regulatory authorities.

Key words: Environment, food and water, hygiene, health, risk assessment

INTRODUCTION

Sylhet is a developing city and a very attractive place for tourism. The city is very rich in natural resources and also attracts tourists and business entrepreneurs. Thus, it is imperative that the city maintains a health friendly environment, clean water and food. Since unclean water and food, poor sanitary and hygiene facilities in restaurants of the city remain a potential source of diseases and risk to human health, the present investigation aimed at studying water and food quality as well as sanitary conditions at selected restaurants of Sylhet city, along with determination of water quality of the major sources of water supply to the city Surma River and tube wells (ground water).

According to Sylhet City Corporation, the city has 331 registered/licensed restaurants, however, many unregistered restaurants also exist. According to a survey by Ahmed and Rahman (2000), only 15% restaurants maintain sanitary facilities, whereas unhygienic conditions that are unsafe for public health prevail in 85% of the restaurants. Although A Bangladesh Standard code of Hygiene also exists (BDS, 1975), most restaurants and similar establishments have failed to conform to the code. An assessment of water and food quality in restaurants of Sylhet city has hardly been done, barring the study by Das and Rahman (2005).

In this paper, food contamination by pesticides and associated health risks due to pesticide residue in food has been analyzed. The present investigation

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was undertaken keeping in view the paucity of similar studies in the past.

Fig.1: Location of sites in Sylhet City

MATERIALS AND METHODS

As stated earlier, there are about 331 authorized or licensed restaurants in the Sylhet City Corporation area. These were selected during 2001 to 2004 for laboratory tests of physicochemical parameters of their drinking water supply system and for a questionnaire survey to assess the quality of their sanitary/hygiene and food handling facilities.

Samples of drinking water from restaurants

The samples from the restaurants water supply system (including tube wells) were collected in sterilized plastic bottles and analyzed for sodium, potassium, calcium, magnesium, bicarbonate, iron and chlorine and ammonium ions, using standard methods (APHA, A.W.W.A., WPFC., 1989) and also for dissolved oxygen (DO), pH and total coliform bacteria (TCB). Dissolved oxygen was measured by dark bottle method and ELE Biological Kit Box determined TCB. Measurements of the pH and temperature were done electrometrically using a digital pH meter (HANNA, HI 8014). Two buffer solutions of pH 4.0 and 7.0 were used to calibrate the pH meter.

Samples of water from Surma River

The samples of water were taken from the Surma River at five points during the dry and monsoon seasons. These were analyzed for iron, lead, chromium, zinc and copper using standard methods (APHA, A.W.W.A., WPFC., 1989). Electrical conductance of water was measured using a conductivity meter and water hardness was determined as $CaCO_3$.

Analysis of groundwater relative to waste dump

Samples of groundwater (tube wells) in the solid waste dumping area were taken from 12 deep tube wells (DTW) and 8 shallow tube wells (STW) from Lalmati area of Sylhet and analyzed for physicochemical parameters during 2001-2002. Analyses were carried out for calcium, magnesium, sodium, potassium, iron, bicarbonate and chlorine. The samples collected from the solid waste dumping site, areas near it and areas remote to it (Within means 10ft from boundary of dumping places. Near means 50ft from boundary of dumping place. Remote means 100ft from boundary of dumping places) were analyzed for pH, temperature, electrical conductivity, total alkalinity, hardness, turbidity, total solids, dissolved solids suspended solids, chemical oxygen demand (COD), dissolved oxygen (DO), chloride, sulphate, phosphorous, fluoride, calcium, magnesium, sodium, potassium, iron, nitrate and total nitrates. A digital turbidity meter (HANNA) was used for determination of turbidity.

Numerical calculations (correlation analysis) for data relative to the dumping site were carried out by SPSS (Statistical Program for Social Science) as follows. Taking X and Y as two variables (within the dumping place and ground water parameter ratio values, the correlation coefficient (r) between X and Y was determined by Pearson's correlation coefficient (Chatterjee and Prince, 1995).

$$r = \frac{\sum xy}{\sum x^2 (\sum y^2)}$$

where x=X- mean of X

y= Y-mean of X

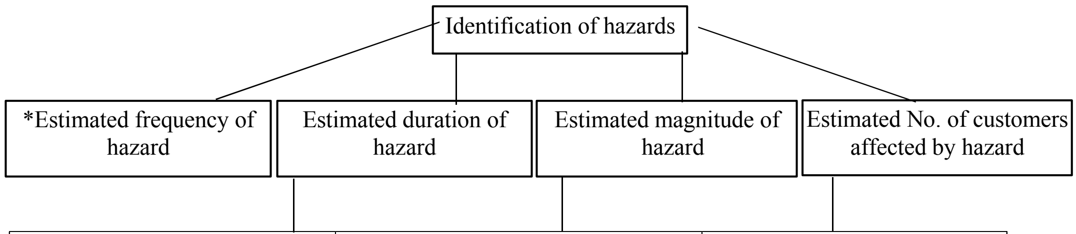
Study of sanitary facilities at restaurants and food handling

Sanitary facilities at the various restaurants selected in this study were also examined.

The facilities assessed were availability or lack thereof of hand washing facilities, running water, soap, towels and disposal of waste. The study also included examination of food source, its preparation and handling.

Risk assessment

Risk assessment was performed according to the method of Han *et al*., (1998). Taking help of experts of EPA (Environmental Protection Agency), a face to face technique was adopted. Empirical data were collected by sample survey method (The survey work was carried out based on a questionnaire, surveyors asked questions to the customers and owners of hotels to fulfill the quarries), seeking the opinion of 36 EPA experts. Based on several meetings of the team members, an interim checklist was developed. To know the relative importance of one criterion over the others, initial weightage was given to the number of parameters under consideration (Fig. 2). The experts were asked to rank the criteria (such as duration of the hazardous class of 2-4 months) according to their importance. The weightage of individual criteria was calculated by multiplying the initial weightage of the criterion by the no of respondents followed by calculation of the final weightage (Rostow, 1960; Papacostas, 1989; Chatterjee and Prince, 1995).



Convert to scores		Convert to scores	Convert to scores	
Score	Duration Information	Biological	Score	Customers affected
2	1-14 days	8= Pathogens present	2	8,000
4	14-30 days	250= Some health affects	4	15,000
8	1-2 months	Chemical	8	30,000
16	2-4 months	8= Present above guidelines	16	65,000
32	4-8 months	32= Low level health effects	32	125,000
64	8-12 months	250= High level health effects	64	250,000
125	1-2.5 years	Aesthetics	125	500,000
250	2.5-5 years	8= Aesthetics problems	250	1,000,000
500	5-10 years	32= Aesthetics problems and	500	2,000,000
1000	10 years or more	above guidelines	1000	4,000,000

(Duration score × WF) + (Magnitude score × WF) + (Customer score × WF)
Frequency of event/year × Consequence factor = Risk Score

**Health Risk Calculation for Iron*

$$\text{Risk} = (\text{CDI} - R_fD) \times SF \qquad (1)$$

$$\text{CDI} = \text{Conc (mg/L)} \times \text{Intake (L)} \times \text{Exposure frequency (EF, Unitless)/body weight (BW)(kg)} \qquad (2)$$

where, Risk = a unit less probability of an individual developing cancer over a lifetime;
CDI= chronic daily intake or dose (mg/kg/day);
R_fD = appropriate route specific reference dose for the toxicant expressed in mg/kg/day and
SF = slope factor expressed in mg/kg/day

Value of SF

1. For Arsenic = 1.5 E^{+00} (for oral), 1.58 E^{+00} (for dermal).
2. For Iron = 1.5 E^{-3}.

The following equation was used to calculate the value of CDI.
CDI=CW × I × EF/BW

Fig 2: Identification of hazards for risk assessment (Han *et al.* , 1998)

Table 1: Values of the parameters used in calculation of CDI and explanations (EPA, 2001)

Variable	Value used	Explanation/source
CW= Concentration in water	Specific (mg/L)	Concentration is obtained from sample data
I= Intake	2L	Average intake for an adult
EF= Exposure frequency	0.68	OSWER Directive
BW= Body weight	70 kg	Adult

Health risk from fish and vegetables washed with surface water

For calculation of health risk due to contaminated food used in restaurants/hotels, the fish samples and vegetables were colleted from Sylhet city and tested for pesticide residues. As carbofuran and endosulfan are used on a wide scale in the Sylhet region, the tests were carried out for only these two pesticides.

RESULTS

Water quality at restaurants

In the case of DO, the standard for sustaining aquatic life is 4 mg/L, whereas for drinking purposes it is 6 mg/L. The values of DO for Sylhet City ranged between 5.52 mg/L (dry season) and 5.72 mg/L (monsoon season) (Table 2), which were well above the range for sustaining aquatic life and close to the values for drinking water (4.0 mg/L and 6.0 mg/L, respectively BDS, 1975). The mean values of pH were 6.1 for the dry season and 6.09 for the monsoon season (Table 2), respectively, indicating acidic condition of water. The standard range of pH for any purpose is deemed to be 6.5-8.5 (Muyan, and Mamun, 2003). The mean values of TCB varied between 24.6 MPN/100 m/L (dry season) and 22.5 MPN/100 mL (monsoon season) (Table 2) levels that are clearly unsafe as far as drinking water is concerned (Alam, 1996). The source of TCB in the water supply of the restaurants appears to be contaminated water storage tank.

The values for ammonia ranged between 0.18 mg/L (dry season) and 0.12 mg/L (monsoon season) (Table 2), the permissible of which according to Bangladesh Standard (BDS, 1975) is 0.5 mg/L. Thus ammonium ions in the drinking water were in the safe range. The mean value of water conductance for Sylhet city is known to range between 80.5-84 µs. Electrical conductance of water was measured using Water Test HANNA 351617.

Table 2: Mean values ($\pm$ standard deviation and range) of various parameters of water quality of restaurants of Sylhet City

DO (mg/L)		pH		TBC		NH_3 (mg/L)	
Dry	Monsoon	Dry	Monsoon	Dry	Monsoon	Dry	Monsoon
5.52 $\pm$ 1.40 (3.50-7.20)	5.72 $\pm$ 1.42 (3.60-7.60)	6.13 $\pm$ 0.29 (5.86-6.86)	6.09 $\pm$ 0.33 (5.70-6.90)	24.60 $\pm$ 13.51 (11.0-46.0)	22.50 $\pm$ 14.44 (10.0-51.0)	0.18 $\pm$ 0.09 (0.08-0.35)	0.12 $\pm$ 0.07 (0.04-0.23)

Of all the essential and trace elements measured in the drinking water of the restaurants, only Fe exceeded (Table 3) the WHO permissible limit and hence rendered it unsafe for human consumption. The permissible safe limits for various physicochemical parameters and pesticides in drinking water are shown in Table 4 (BDS, 1975).

Quality of surface water from Surma River

The electrical conductance at five points of Surma during the monsoon season was 100µs, 105µs, 108µs, 110µs and 120µs towards the North direction of the city. In the dry season it was 800µs, 830 µs, 759 µs, 810 µs and 850 µs towards the North direction of the city. Thus the conductance values for the dry season were substantially higher than those for the monsoon season. Since conductance depends on the number of ions present in water, the total volume of water decreases in the dry season and hence high value of conductivity in this season. Hardness (as $CaCO_3$) of Surma River water increased along the southern direction and ranged between 30.2 and 70.2 ppm. Although the value for the monsoon season was higher, these values were within the safe limit for drinking water.

Table 3: Essential and trace elements in water supply of restaurants of Sylhet city. DTW= deep tube well; STW= shallow tube well; Source: Muyan and Mamun, 2003

Sources of water	Ca^{++} (mg/L)	Mg^{++}(mg/L)	Na^{+}(mg/L)	K^{+}(mg/L)	Fe^{+}(mg/L)	HCO^{-}_{3}(mg/L)	Cl^{-}(mg/L)
DTW	96.6	47.52	48.3	2.73	0.41	294	55.73
DTW	74	45.32	44.85	14.82	0.38	182.28	33.37
DTW	29.8	64.02	27.37	17.94	0.84	233.24	79.87
DTW	20.8	10.12	22.08	26.52	0.76	226.87	72.77
DTW	42.8	44.44	11.04	8.19	0.26	403.27	45.44
STW	48.8	46.64	10.58	7.80	0.13	435.12	96.91
DTW	71.6	45.98	19.32	6.24	1.14	280.77	105.79
STW	47.8	48.62	9.43	3.90	2.19	293.02	61.77
DTW	46.2	57.20	18.4	2.34	0.21	363.58	91.23
STW	58.6	58.30	19.55	2.73	0.28	267.05	64.96
DTW	58.6	29.48	18.44	1.56	4.39	339.57	31.95
STW	47.8	18.48	18.63	1.95	5.83	347.90	142.00
STW	35.2	14.96	2.53	-	0.46	112.70	51.47
DTW	1.02	0.62	0.18	-	0.40	4.73	2.03
STW	0.69	0.77	0.18	-	0.32	2.59	1.60
DTW	1.52	0.76	0.10	-	0.13	3.10	1.70
STW	1.53	0.68	0.11	0.08	-	2.70	2.61
DTW	1.10	0.38	0.14	0.06	-	2.21	2.89
STW	0.90	0.27	0.14	0.02	3.99	2.93	1.73
DTW	0.70	0.47	0.14	0.03	-	3.87	1.45

Table 4: Various drinking water quality standards (Alam, 1996)

Parameter	Drinking Water Quality as per		
	EQS standard	WHO standard	EC standard
pH	6.0-8.5	6.5-8.5	6.5-8.5
TDS (mg/L)	1,000	1,000	1,000
Iron (mg/L)	0.3-1.0	0.3	0.20
Sodium (mg/L)	200	200	175
Chloride (mg/L)	150-600	250	250
Sulphate (mg/L)	400	400	25
Fluoride (mg/L)	1.0	1.5	1.5
Arsenic (mg/L)	0.05	0.05	0.05
Ammonium (mg/L)	0.5	1.5	0.5
Nitrate (mg/L)	10	10	10
Phosphate(mg/L)	6.0	-	5.0
Potassium (mg/L)	12.0	-	10
Endrin (μg/L)	0	0.2	0.2
Heptachlor (μg/L)	0	0.1	0.1
DDT (μg/L)	0	1.0	0.1

Table 5 shows values of various metals in the surface water collected from 5 different points of Surma River. Although surface water is not used for drinking purposes, it is used for washing purposes. The concentration of chromium was within the 38.2 ppb (Shiddiky, 2002) upper safe limit in our present study. This level of chromium was thus much below the permissible limit for irrigation and livestock drinking as recommended by EU (Shiddiky, 2001) and BD (BDS, 1975). In this respect, the surface water of Sylhet city is not polluted by Cr. Shiddiky (2001) reported that the concentration of chromium in Surma river as 20.6 ppb. The standard limit of lead for domestic and irrigation water is 50 ppb. Zinc concentration was maximum at Surma River downstream during the dry season (1.48 ppm) and minimum upstream during the monsoons (0.002ppm). It was thus higher in the dry season than in the monsoon season. The effluent discharge from industries, various domestic and household sources enhance the concentration of zinc during the dry season. The concentration of copper was within the 4.2 ppb in our present study. Its level was much below the permissible limit for irrigation and livestock drinking as recommended by EU and BD (BDS, 1975). The standard limit of copper for domestic and irrigation water is 1.0 ppb (Shiddiky, 2001). In this respect, the Surma River is not polluted in terms of copper. Shiddiky (2001) reported that the concentration of copper of Indus river of Pakistan.

Table 5. Heavy metals in surface water samples from 5 points of Surma River during dry and monsoon periods

Sample point	Fe (ppm)		Pb (ppb)		Cr (ppb)		Zn (ppb)		Cu (ppb)	
	Monsoon	Dry	Monsoon	Dry	Monsoon	Dry	Monsoon	Dry	Monsoon	Dry
1	0.90	0.28	13	13	38	38	2.59	843.8	4.2	4.2
2	1.10	0.31	13	13	38	39	3.43	1212.2	4.2	4.2
3	1.64	0.33	13	13	36	40	3.37	961	4.2	4.2
4	2.37	0.45	13	13	38	38	4.58	1310	4.2	4.2
5	3.16	0.30	13	13	38	39	6.77	1443.1	4.2	4.2

Groundwater pollution by solid waste dumping

The results of this analysis are shown in Table 6, where data for within and near the dumpling area and areas remote to the dumpling place are listed.

Table 6. Comparison of water quality within, near and remote areas of the dumping site

Parameters	Average concentration of water samples within dumping place	Average concentration in groundwater near dumping place	Average concentration in groundwater remote from dumping place
pH	6.65	7.7	7.9
Temperature (^oC)	29.2	25	26
Conductivity (mmhos)	4.73	2.22	0.79
Total solids (mg/L)	34230	1470	570
Total dissolved solids (mg/L)	32890	1080	350
Total suspended solids (mg/L)	1540	394	216
COD (mg/L)	39060	52.0	3.2
DO (mg/L)	1.5	4.8	7.3
Total alkalinity (mg/L$CaCO_3$)	625	217	221
Chloride (mg/L)	3458	280	46
Sulphate (mg/L)	2455	288	108.3
Phosphorous (mg/L)	83	8.72	0.7
Fluoride (mg/L)	1.5	3.8	1.44
Nitrate (mg/L)	1.45	0.31	0.086
Hardness (mg/L)	4564	610	204
Calcium (mg/L)	970	114	58.67
Magnesium (mg/L)	515	78	14.03
Sodium (mg/L)	164	110	16.94
Potassium (mg/L)	6276.5	24	2.9
Iron (mg/L)	133.5	1.48	0.21
Total Nitraten (mg/*L*)	283.75	25	14.8

Correlation study of groundwater relative to dumping site

The highest correlation (r= 0.87) was observed for <within the solid waste dumping place vs. ground water near the dumping place>, while the lowest correlation (r= 0.607) was recorded for

<within the solid waste dumping place vs. ground water remote to the dumping place> (above 2250 cm). A high correlation value indicates the extent of ground water pollution by dumping of solid waste effluents. It is evident from the observations that 75.69% (coefficient of determination r^2= 0.7569) variation in the value of ground water near the dumping place was associated with the variation in the value of water quality within the dumping place.

Sanitary facilities

The present condition of different restaurants of Sylhet City Corporation area is shown in Table 7. It is evident that most requirements of sound sanitation were lacking in most restaurants.

Table 7: Sanitary facilities at hotels of Sylhet city

Sanitary facilities	%
Toilets absent	40
Toilets located outside the restaurant	25
Separate toilets for each sex	15
Well cleaned toilets	35
Soap at toilets	30
Soap at washing basins	85
Towels provided	55

Food source, preparation and storage

Fig. 3 shows that only 10% restaurants kept their food covered while the remaining ones kept it in open trays. Only 20% restaurants disposed off their unsold food, whereas others served the unsold food to their employees. Most restaurants purchased food items from open market rather than from authorized sources and cold storage facilities were also lacking at a noticeable proportion of restaurants.

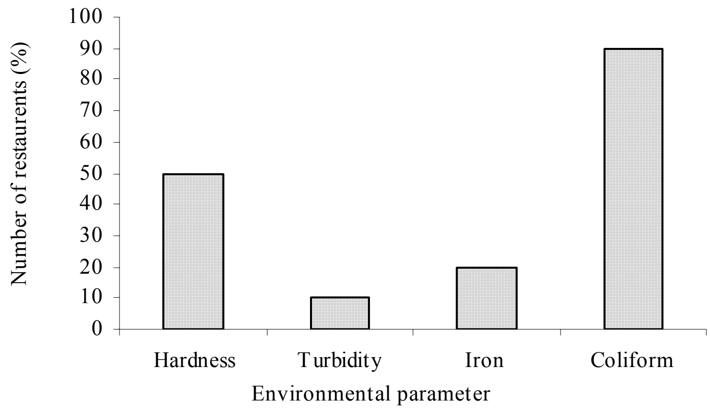


Fig. 3. Food source, preparation and storage facility and its disposal at different restaurants

Sanitary system

The survey of the various restaurants revealed that most restaurants maintained substandard sanitary/hygiene facilities (Table 8). Only 30% cared to dispose off their waste in the municipality bin (Table 8). Water drainage, trash bin and kitchen cleaning facilities were very poor at most restaurants.

Table 8: Status of sanitation facilities at restaurants

Sanitation facilities	%
Well drained system	20
Waste stored in trash bins	30
Bins cleaned daily	10
Kitchen washed daily	30
Solid waste disposed into Municipal bin	70

Water supply at restaurants

Table 9 shows that 70% restaurants served only tap water (groundwater) to their customers and only 40% had adequate water supply. Regular tests of water quality were done at very few restaurants (10%). Municipality water was available only at slightly over 50% restaurants.

Table 9: Source* and type of drinking water provided to customers by the restaurants (%)

Source and type of drinking water	%
Connected with Municipal Water Supply	55
Provided adequate quantity of water	40
Mineral water	60
Only tap water	70
Test of water quality regularly	10

* Source: Das and Rahman , 2005.

Laboratory tests (Fig. 4) showed unsafe levels of turbid water (0.09% restaurants), iron (22.7% restaurants) and total coliforms (100%) at a noticeable percentage of restaurants. According to the Department of Environment (DOE) report as well coliform bacteria exist in drinking water at 100% restaurants.

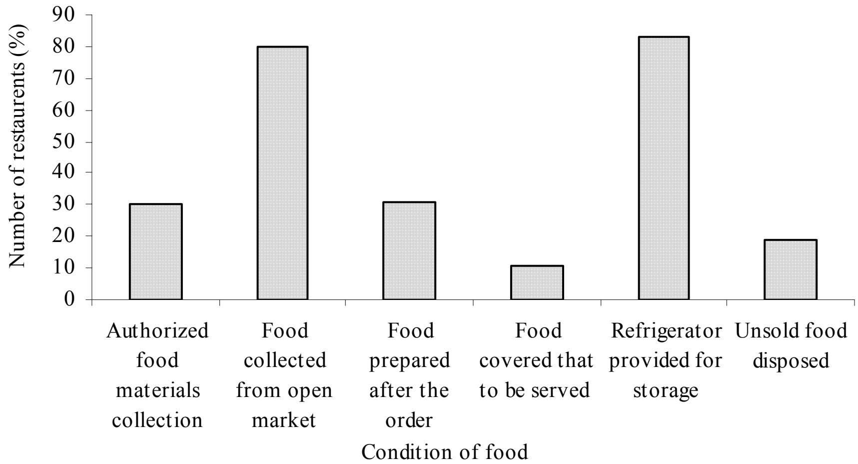


Fig. 4. Analysis of water quality at restaurants of Sylhet city

Risk assessment of various parameters

Iron

From Eq. 2 (see Methods), CDI=0.0493 mg/kg/day. Since the R_fD value for iron is higher than the calculated CDI value, the risk calculated based on Eq. 1 (see Methods) was insignificant. In this case, the average value of iron concentration was considered for the whole city. However, practically there is a fluctuation in the concentration of iron among the various restaurants. For Sylhet City, the geometric mean concentration of iron (μ_g) and the geometric standard concentration σ_g of iron were found to be 2.15 ppm and 1.5 ppm, respectively. From the report collected from Osmani Medical College and the Department of Environment during different periods, the relationship between iron concentration and percent of people affected from the water borne diseases is shown in Table 10 and Fig. 5.

In order to find out the parameters of dose response curve for contaminants (e.g iron), the following equations developed by Saltzman (1997) were used.

$$\text{Log } 1.95 = \text{Log } \sigma_R \, (-2.326) + \text{Log } C_{50}$$
$$\text{Log } 2.57 = \text{Log } \sigma_R \, (-1.645) + \text{Log } C_{50}$$

From the above equations, $\sigma_R = 1.50$ ppm and $C_{50} = 5.00$ ppm, Where C_{50} = concentration equal to D_{50} divided by the concentration averaging time and σ_R = geometric standard deviation of the dose response curve. In order to calculate joint probability of the concentration and the responses from overlapping curves, the variability ratio (V) and the safety factor (SF) exponent (E) were essential,

$$V = (\text{Log } \sigma_g / \text{Log } \sigma_R) \text{ and } E = \{\text{Log } (C_{50}/\mu_g)/\text{Log}\sigma_R\}$$

Table 10: Percentage of people affected due to iron contamination

Fe concentration (ppm)	% of people affected from iron contamination
0.5	0.25
1.0	0.45
1.5	0.78
1.95	1.00
2.00	1.25
2.10	1.53
2.20	1.98
2.30	3.12
2.40	4.20
2.57	5.00
2.70	6.02
2.82	7.21

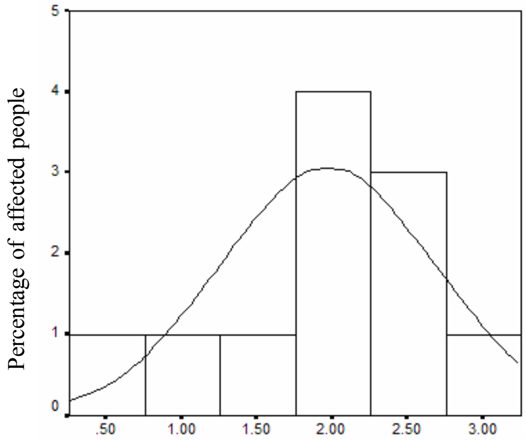


Fig. 5: Fe concentration in mg/L

Where μ_g = observed geometric mean concentration (hourly) = 1.97 mg/L and σ_g = observed geometric standard concentration (hourly average)= 0.72 mg/L (from the Table 10)

V= 1.672 and E= 4.779

From the Saltzman curve (1997), the P_{CR} (joint probability of he concentration and responses) = 2.13×10^{-8}.

Risk of an adverse effect within a year = 8760 × P_{CR} = $1.862.0 \times 10^{-4}$

The value obtained was insignificant indicating no risk from iron.

Total Coliform Bacteria (TCB)(see Methods)

Consequence Factor = (Duration score×WF) + (magnitude score×WF) + (Customers scores×WF) (1)

Risk score = Frequency events/year × Consequence factor (2)

Duration score = 16 [2-4 months]
Magnitude score = 250[Biological]
Magnitude score = 8 [Chemical]
Total magnitude score = 46.36
Customer score = 11(by interpolation)

From Eq. 1 (see Methods), the Consequence Factor = 49.159; Assuming frequency events/year=30 days/year (Minimum value), then from Eq. 2:
Risk score = 1474.77.
Since the risk score is greater than 1000, the risk is high (according to EPA, 2001).

Fish and vegetables washed with surface water (Surma River)

For calculation of health risk due to food used in hotels, the fish samples and vegetables were colleted from Sylhet city and tested for pesticides. As carbofuran and endosulfan are used in wide scale in Sylhet region, tests were carried out for these two pesticides. These pesticides are found in significant amount in fish and vegetables in the Sylhet zone (Table 11) (Alam, 1996).

Table 11: Pesticide residues in fish and vegetables of Sylhet city

Fish	Carbofuran (ppb)	Endosulfan (ppb)
Taki	4.9	227.5
Gutum	0.10	12.1
Vegetables	not significant	0.0331

Pesticide toxicity due to consumption of contaminated food (fish and vegetables)

Residue of endosulfan in human body due to consumption of fish was calculated based on the following equation taken from Alam (1996).

$C_b = B \times \alpha \times \delta \times d \times \exp(a\text{-}kt)$

Where d = daily consumption per person; C= exp (a-kt) = pesticide residue level in fish, α = 1 – percentage of DDT (Endosulfan) removed by washing and cooking (range 70-80%) = 27%; δ = Digestion factor (40-50%) = 50% (Tyugh, 1989); B= percentage of pollutant remaining in food after storage (range 80-85%) (Saifullah, 1994); d = 227.63 ppb=2.28 mg/kg.

$C_b = 3.84\times10^{-3}$ mg/day

DISCUSSION

The present investigation on the quality of water used in restaurants, tube wells and Surma River show that it was highly unsafe for human consumption. The levels of iron, zinc and coliform bacteria in drinking water exceeded the permissible limits established by WHO/EU/BD standards. The calculated CDI was 0.0493 mg/kg/day. Since the RfD value for iron was higher than the calculated CDI value, risk calculated appeared insignificant. It is, however, noteworthy that in the present analysis for iron the average value was taken for the entire city. In reality, there is fluctuation in concentration of iron in the drinking water among the various restaurants, and hence high values at some of these restaurants may pose risk to the consumers. The risk score for coliform bacteria was 1,474.77, which indicates high risk according to WHO standards. In order to stem the risks to human health due to water and food contamination, it is imperative that the effluent discharge from industries, various domestic and household sources (which enhance levels of heavy metals and pesticides in the city's water supply, especially during the dry season) must be controlled through vigorous efforts. Improper dumping of solid waste seems to be a significant cause of deterioration of water quality at restaurants and the city of Sylhet in general. Correlation analysis of association between the waste dumping site and source of water revealed that contamination is significantly in water that is closest to the waste dumping site ($r= 0.87$). As much as 75.69% (coefficient of determination $r^2= 0.7569$) variation in the value for ground water near the dumping place was found to be associated with the variation in the value of water quality closest to the dumping site.

In terms of the sanitary facilities, food handling and availability of clean drinking water at restaurants of the city, the situation appears to be deplorable. Unfortunately, laws for strict regulation of sanitary and hygienic facilities at restaurants in Bangladesh have not yet been framed. Pure Food Ordinance was promulgated in Bangladesh in 1959, but most restaurants have ignored it. Furthermore, there is no regular monitoring of restaurants by the municipal or other authorities of the city. Unless immediate measures are taken to improve the current situation, the restaurants of the city would continue to pose threat to public health. Hungary, a European country, provides a good example of how environmental dilemmas can be solved by special measures. In the South plains of this country, there are large areas where drinking water contains unsafe levels of ammonium and arsenic ions (Hodi, 2000). These ions are accompanied by high amounts of humic acids and dissolved gases. Poor efficiency of detoxification is achieved when chlorine is used for detoxification of water due to its reaction with the contaminants. To overcome this problem, every hotel has installed small sized treatment plants for removal of pollutants such as arsenic and ammonium (Hodi, 2000). Bangladesh also needs to tackle its difficult environmental concerns by using similar approaches and by strict regulatory measures. It is hoped that the present study would help in enhancing awareness of the public and government authorities of the grave health risks arising from substandard water and food supply system in Bangladesh and apathy of the market in general towards human health.

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