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Water Quality Towards Indexing the Drinking Standard of Bottled Water

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ABSTRACT

Access to safe drinking water is one of the major concerns around the globe. Due to enormous shortage and unavailability of quality water dependence on bottled water has been growing continuously. The study aims at to evaluate the water quality for suitability from different available sources of drinking water such as branded bottled water (BBW), local bottled water (LBW) and water from public accessible places (PAP). The water quality index (WQI) is evaluated and taken as the guiding parameter. Different water quality parameters (physical, chemical and biological). The result showed that the water quality varies for different water sources and fell into excellent, good, fair and poor categories as per WHO guidelines. The result showed that 98% of BBW, 80% of LBW and only 70% of PAP are excellent for drinking purposes. The study recommends enormous scope of entrepreneurship development of bottled drinking water, maintaining the quality criteria of drinking standard.

Keywords : Water Quality, Drinking Water Standard, Water Quality Index, Water Quality Categories, Entrepreneurship Development

I. INTRODUCTION

Fresh water for consumption is essential for human sustenance on the earth. Availability of water, safe and hygienic, particularly for drinking and other related daily purposes is becoming critical day by day. Different anthropogenic activities arising out of urbanization, farming, over-extraction of groundwater and deforestation has caused ecosystem degradation, affecting different components of the hydrological cycle [1]. A continuous growth in human population together with rising living standards is the leading cause of existing water resources depletion [2]. Groundwater, the prime of fresh water for different human activities like irrigation, domestic and industrial purposes are getting depleted. The major driver of groundwater depletion is irrigation which accounts for 70% of the total water available and the increment of groundwater extractions is estimated to be

1100 km^3 per year by 2050 as compared to 800 km^3 per year as of 2010 [3]. Several billion people worldwide are estimated for not getting adequate water. Moreover, load of pollutants in groundwater via infiltration of sewage and industrial waters in addition to contaminated surface water sources in several countries over the earth is increasing at an alarming rate [4-7]. Thus, water quality has a direct impact on the human health [8]. Water quality generally implies the physical, chemical, and biological characteristics of water. Water quality is described as a measure of the condition of water in terms of the requirements of one or more biotic species including human being.

Availability of fresh and safe drinking water is a prime demand and right for all human beings. However, in several urban areas of India along with different countries are facing acute shortage of drinking water. In order to combat the situation different business companies are manufacturing and marketing packaged and bottled drinking water. This is popular among the medium and low-income groups, particularly during their travel. Packaged waters generally contain minerals, naturally occurring or intentionally added; may contain carbon dioxide, naturally occurring or intentionally added; but shall not contain sugars, sweeteners, flavorings or other food stuffs.

Bottled water is generally considered safe for usage provided it meets the quality criteria and specifications [9]. In a moderate estimate usage rate of bottled drinking water in parts of Asia is around 27% and India is rated among the top ten countries in the world [10]. Thus, manufacturing industries of bottled water are one of the fastest growing industrial sectors in not only India but in this part of the world. As a rough estimate there are more than 4000 bottling plants throughout India and new installations are also coming up [11]. However, with increasing demand, serious concerns about its quality and safety have arisen subsequently, as in some cases violations of national standards [12] are coming in surface of news. Several health disorders due to consumption of some spurious bottled water and outbreaks of waterborne diseases such as cholera, typhoid, and hepatitis A and E are reported [13].

Demand for bottled water has resulted in springing up of several small-scale entrepreneurs involved in its production and distribution. However, with increasing demand, serious concerns about its quality and safety have arisen subsequently. The manufacturing plants of most companies of bottled water in India are situated in unhygienic locations like agricultural fields or estates. Most companies use bore wells as source of water. Here, water is pumped out from depths varying from 80 to 500 feet below the ground. The less likely sources of packaged water are from public drinking water systems such as Municipality supply water [14]. Ground water has quality problems due to salinity (particularly in coastal areas) and contaminants like agrochemicals, pesticides, nitrates, fluoride, iron, and arsenic. The ground water available in about one-third of India's districts was found to be unfit for drinking. This was because of the presence of contaminants exceeding the tolerance levels [15, 16]. Significant levels of contaminants have been reported in fresh water systems and in the bottled water samples collected from some major cities in India. These observations imply that the technology currently being used for treating raw water is insufficient to have safe water for consumption. Hence, periodic surveillance of packaged drinking water like bottled water is very much essential. This will serve the dual purpose of monitoring the standards of bottled water production industries as well as help in giving reassurance of quality to users [17].

II. METHODOLOGY

2.1. Protocols: Water quality parameters

Evaluation of water quality parameters, particularly for drinking water is very important and the quality is judged by i) physical parameters: color, odor,

temperature Turbidity, Solids, Electrical conductivity (EC);

ii) chemical parameters: pH, acidity-alkalinity, hardness dissolved oxygen, biochemical oxygen demand (BOD), chemical oxygen demand (COD), chloride, residual chlorine, sulfate, nitrogen, fluoride, iron, mercury, lead, arsenic etc.; and

ii) biological parameters: bacteria, algae, viruses, protozoa load.

2.2. Instruments

The principle and the instruments used for different water quality parameters are presented in Table 1.

Table 1: Analytical methodologies for evaluation of water quality parameters [18]

Parameter	Principle	Instrument
Color & odor	Appearance	
Turbidity, TDS	Gravimetry	Portable multimeter
pH	Potentiometry	pH meter
EC	Conductometry	Conductivity meter
Na(I), K(I)	Flame emission	Flame photometer
Chloride, fluoride, sulfate, nitrate, nitrite	Ion exchange	Ion Chromatography
Hardness,	Complexometry	Burette titration
Ca(II), Mg(II)	Complexometry	Burette titration
Fe(II & III), Cd(II), Hg(II), As(III & IV)	Atomic absorption	AAS
Phosphate	Molecular absorption	UV Spectrophotometer
Faecal coliform	Count	Laminar flow

2.3. Water quality index

The overall quality of water is more critically assessed by the water quality index (WQI) considering the water quality data of the studied samples [19]. The Brown model of WQI, [20] as was supported by the National Sanitation Foundation also known as NSFWQI, can be calculated by the weighted arithmetic index method

The Water Quality Index (WQI) has been calculated by using the following equations [21]:

$$WQI = \Sigma QiWi / \Sigma Wi \quad (1)$$

The quality rating scale (Qi) for each parameter is calculated by using the following equation:

$$Qi = 100[(Ci - C0)/(Si - C0)] \quad (2)$$

where, Ci =estimated concentration of i-th parameter in the analysed water sample

C0=the ideal value of this parameter in pure water

Si = recommended standard value of the i-th parameter

The unit weight (Wi) for each water quality parameter is calculated by using the following formula:

$$Wi = K/Si \quad (3)$$

where K, the proportionality constant, can be calculated by using the following equation:

$$K = 1/\Sigma(1/Si) \quad (4)$$

Each parameter has been assigned a weight (wi) according to its relative importance in the overall quality of water for drinking purposes. The maximum weight of 5 has been assigned to the parameter coliform due to its relative importance in water quality. The principal risk to human health derives from fecal contamination [9].

2.4. Sample selection and sampling

Water samples are collected in 1000 ml polyethylene bottle in two sets (with and without preservative) for different water sources of public accessible place (PAP1-PAP10) viz, railway station platforms between Sealdah to Kalyani (22.5678° N, 88.3710° E to 22.9747° N, 88.4337° E) in North suburban section of West Bengal. Ten different branded bottled water (BBW1-BBW10), and ten different local made bottled water LBW1- LBW10) commonly available and popularly purchased by the local people are collected for analysis. The bottles of each brand were from ten different vendors selected randomly, analyzed in triplicate and the mean value was taken. The water from PAP was collected at ten different occasions and are analyzed in triplicate and the mean value was taken. All the branded bottled water has marked IS no.14543.

III.RESULT AND DISCUSSION

The procured drinking water bottles are analyzed following the standard protocol [18]. The pH, electrical conductivity, total dissolved solids, Total hardness, calcium, magnesium, Chloride, phosphate and Faecal coliform bacteria for all the thirty samples each with triplicate has been analyzed. The range of the data corresponding to each parameter are presented in Table 2.

All the samples are found free of arsenic and phosphate load. All other parameters are within the WHO Guidelines for drinking water quality for BBW. However, the LBW have TDS and TH generally high. The EC, TDS, TH, Ca^{2+}, Mg^{2+}, Fe, Cl^- are found higher than the recommended value (21) for PAP. In 7% cases the PAP samples contained Pb(II), may be from the pipe lines. Moreover, a few samples (1%) have found contaminated with low level count of Faecal coliform bacteria.

Table 2. Analytical data for water quality parameters of some selected local bottled water

Parameter	Source		
	BBW (IS: 14543)	LBW	PAP
Color & odor	Nil	Nil	Nil
pH	6.15-7.11	5.87-7.34	6.58-7.22
EC (µs/cm) 25°C	86-221	112-198	489-2125
TDS (mg/l)	61-155	85-183	412-958
TH (mg/l)	40-90	123-287	311-584
Ca^{2+} (mg/l)	3.34-12.23	18.34-20.35	20-70
Mg^{2+} (mg/l)	0.67-5.78	3.44-6.21	32-123
Fe (total) (mg/l)	2.34-3.56	8.12-14.32	22.12-141.0
As^{3+}	BDL	BDL	BDL
Hg^{2+} (mg/l)	BDL	BDL	BDL
Pb^{2+} (mg/l)	BDL	BDL	Detected in 7 % cases
Cl^- (mg/l)	1.13-1.56	2.98-5.11	30-165
PO_4^{3-}	BDL	BDL	BDL
Faecal coliform	BDL	BDL	Detected in 4% cases

In order to find the suitability of the water for drinking the overall quality of water was assessed from the WQI value [22], calculate from Eq. 1-5. The WQI values are found to be in different categories for different sources of the samples collected. Based on the WQI value the water can be categorized (C1 to C4) from excellent to poor [23].

The quality characteristics, based on WQI value, of different sources (BBW, LBW, PAP) are presented in Figure 1. The higher value of WQI indicates the less suitability of water for drinking. Based on the WQI values, the occurrence of water samples in different categories are presented in Fig 2. The analytical data of WQI for BBW, LBW and PAP are presented in Table 2. It was found that PAP source has poor grade for 4% samples as it contains bacterial load, may be due to some contamination problem or lack of cleaning. Moreover, 7% of PAP samples contained detected level of lead, probably from the water distribution pipeline. Only, 70% of PAP are found of

excellent grade but 80% of LBW source and 98% of BBW were in excellent grade.

Table 2. Occurrence of water samples in different categories

WQI range	Category	Suitability	Occurrence (%)		
			BBW	LBW	PAP
< 50	C1	Excellent	98	80	70
50-75	C2	Good	2	12	16
75-100	C3	Fair	0	8	10
>100	C4	Poor	0	0	4

BBW is almost 98% excellent and 2% is good to drink. In case of LBW only 80 % falls in excellent range rest 12% in good and 8% in fair range. PAP samples are categorized as of low grade for 4% of samples, !0% of samples are fair, 16% are good and only 70% are excellent grade.

IV. CONCLUSIONS

The samples procured were tested for physical, chemical and biological parameters. The water quality parameters were estimated in the first step. The results were finally interpreted in terms of Water quality index (WQI). BBW is almost 98% excellent and 2% is good to drink. In case of LBW only 80 % falls in excellent range rest 12% in good and 8% in fair range. The PAP samples are found as of poor grade (70% excellent, 16% good, 10% fair, 4% poor). Thus, the study suggest that contaminated water need to be purified to make it suitable for drinking. The bottled drinking water has a huge demand and this is increasing day by day. There is ample scope to develop entrepreneurship on packaged and bottled drinking water. Therefore, in addition to proper water treatment before bottling it can further be recommended to take care for the following aspects

i) maintaining good manufacturing processes following standard protocol

iii) protecting bottled water during storage and transport

iv) using of suitable quality of bottle

iv) avoiding contamination after purchase bottled water

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