Information System Framework for analyzing the Consumer Buying Behavior of Water purchases in UAE

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Abstract
Water is vital resource in world as well as to mankind as well. Water purchase decision fall under the category of routine purchase while its pivotal for regulating body thermodynamics along with life of subsistence. The present study revolves around the fact that quality of water in UAE using WQI based on 5 different parameters indicated by Standardization Organization for GCC (GSO). The study is conducted in UAE, a country which struggles for drinking water and the bottled water is a huge business in the region. Geographically the country is located across the Arabian Sea even then the drinking water is a scare element due to high costs of desalination and huge demand due to dry and humid climate. As many as 200 respondents were contacted to reveal their opinion on the awareness levels of various water bottles in UAE. The data was analyzed with the help of suitable programming and statistical tools.

The study reveals the presence of 5 vital parameters defined by GSO in 15 commercially available bottled water and then defines the WQI for each of the brands. Based on the outcomes, using S-I-R model, the average number of consumers buying the particular brand and brand shifting because of awareness campaign were defined mathematically.

1. INTRODUCTION

The water quality in UAE is a subject of ongoing concern. The assessment of various minerals ingredients affecting the water quality is a challenging problem. During the last decades, there has been an increasing demand for monitoring water quality by regular measurements defined by various water quality variables. According to [1], some of the necessities of water quality monitoring are the following:

a) To provide the synopsis of water quality
b) To monitor the selected water quality parameters

Computer systems now offer the leeway of handling and controlling outsized set of records in ways which was not previously was a practical option. [1] Have used the set of records, stored it in databases for estimation of UK river mass loads of pollutants. [2] Studied the hydro-chemical databases in Scotland to study and assess the annual variation in amounts and concentration of mineral thereby examining the water quality. [3] Analyzed the detailed databases for Scotland and identified temporal changes in water quality over the last 20 years.

Because of growing concern that constituents of drinking water may have adverse health effects, consumption of tap water in UAE has dwindled considerably and consumption of bottled water has augmented. Based on the observations, the objectives of the study are:

1) To determine whether WQI of various UAE bottled water, and
2) To analyse the awareness levels amongst consumers for buying the commercially available bottled water in UAE.

We obtained mineral content list from 15 different water brands from commercially available bottled waters and with mineral reference intakes (MRIs).

Complete study is divided into 5 sections as follows: Section 2 identifies the methodologies for analysis of water quality of the commercially available bottled water by identifying the WQI for 15 brands. Section 3 describes the analysis of awareness levels of consumers buying the available bottled water in UAE. Section 4 uses the SIR model to develop the mathematical model. Section 5 gives the outcomes of the result.

2. METHODOLOGY FOR ANALYSIS OF WATER QUALITY

For the analysis of water quality in UAE, 15 commercially available bottled water were analyzed as per the standards of Standardization organization of GCC (GSO standards). The analysis of water quality data for estimation of quality were used for calculation of the WQI (Water Quality Index) values. In order to calculate WQI values, generally, 8 parameters are used, namely,

1. pH value
2. Dissolved Oxygen (DO)
3. Total Dissolved Solids (TDS)
4. Electrical Conductivity (EC)
5. Total Alkalinity (Alk)
6. Total Hardness (TH)
7. Calcium (Ca+)
8. Magnesium

As per the standards set by GSO, the 8 water quality factors GSO standards along with the Unit Weights are mentioned in Table 1.

Table 1: Water Quality Factors as per GSO standards

Water Quality Factors	**GSO Standards (X_i)**	**Unit Weight (W_i)**
pH value	7.0-8.5	0.322
Dissolved Oxygen (DO)	>5	0.548
Total Dissolved Solids (TDS)	<300	0.009
Electrical Conductivity (EC)	<1500	0.002
Total Alkalinity (Alk)	<120	0.023
Total Hardness (TH)	<600	0.005
Calcium (Ca+)	<75	0.037
Magnesium	<50	0.055

Out of these 8 parameters, 5 parameters are used for the study to determine the WQI. These factors are

1. pH value
2. Total Dissolved Solids (TDS)
3. Total Hardness (TH)
4. Calcium (Ca+)
5. Magnesium

The steps for determining the WQI are elaborated in detail in the section.

2.1 Weightage Factor

Determination of Unit Weight (W_i) assigned to each of the water quality factors depends on the fact that factors which have higher permissible limits are less harmful and the factors having lower permissible limits are more harmful. In other words, weightage of factor has an inverse relationship with its permissible limits.

Mathematically, the statement can be stated as:

$$W_i \propto \frac{1}{X_i} \qquad (1)$$

For any constant of proportionality, k, equation (1) can be rewritten as:

$$W_i = k.\frac{1}{X_i} \qquad (2)$$

where, W_i=unit weight of factor, and,
X_i=maximum permissible limits as recommended by GSO, UAE.
The value of k can be derived as:

$$k = \frac{1}{\sum_{1=1}^{5}\left(\frac{1}{X_i}\right)} \quad (3)$$

where, $\sum_{i=1}^{5}\left(\frac{1}{X_i}\right)$ defines the 5 water quality parameters taken for consideration.

$$\sum_{i=1}^{5}\left(\frac{1}{X_i}\right) = \frac{1}{X_i[pH]} + \frac{1}{X_i[TDS]} + \frac{1}{X_i[TH]} + \frac{1}{X_i[Ca+]} + \frac{1}{X_i[MG+]} \quad (4)$$

Once, we identify the weightage factor of the bottled water based in eq. (3) and Table 1, rating factor (RF) needs to determined.

2.2 Rating Factor

The segment ascertains the procedure to outline Rating scale for scheming Water Quality Index (WQI). These scales are prepared for range of values for each of the 5 parameters used for the study. The rate varies from 0 to 100 and is divided into 5 interludes. The rating $X_r = 0$ implies that the parameter present in water exceeds the GSO permissible limits and water is not suitable for drinking. On the other hand, X_r=100 implies that the parameter present in water has the most desirable value. The other ratings fall between these two extreme and are X_r=40, X_r=60 and X_r=80 standing for excessively polluted, moderately polluted and slightly less polluted respectively. This scale of modified version of rating scale was cited in GSO is exemplified in Table 2 and specified by [4].

Table 2: Rating Scale for calculating WQI

Water Quality Parameter	Ranges				
pH	7.0-8.5	8.6-8.7	8.8-8.9	9.0-9.2	>9.2
TDS	0-375	375.1-750	750.1-1125	1125.1-1500	>1500
TH	0-150	150.1-300	300.1-450	450.1-600	>600
Ca+	0-20	20.1-40	40.1-60	60.1-75	>75
Mg+	0-12.5	12.6-25	25.1-37.5	37.6-50	>50
X_r	100	80	60	40	0

Table 3: Rating Scale for Quality of Water

Value of WQI	Quality of Water
80-100	Excellent
50-79	Acceptable
<79	Medium

2.3 Water Quality Index (WQI) calculation

Essentially, a WQI is a compilation of a number of parameters that can be used to determine the overall quality of water. For the study, the parameters involved in the WQI are pH , TDS, TH, Ca+ and Mg+. The numerical value is then multiplied by a weight factor that is relative to the significance of the test to water quality. The sum of the resulting values are added together to arrive at an overall water quality index.

According to [5], the WQI can be evaluated as:

$$WQI = W_i * X_r \quad (4)$$

where, $W_i * X_r$ can be derived as

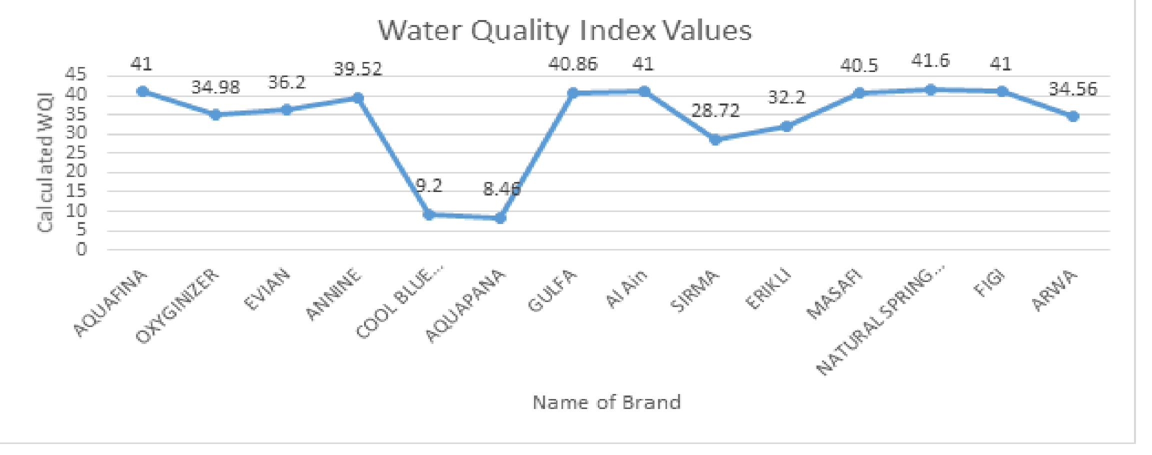
$$\begin{aligned} W_i * X_r = &(W_i[pH] * X_r[pH]) \\ &+(W_i[TDS] * X_r[TDS]) \\ &+(W_i[TH] * X_r[TH]) \\ &+(W_i[Ca+] * X_r[Ca+]) \end{aligned}$$

$$+(W_i[Mg+] * X_r[Mg+])$$

2.4 WQI for bottled water in UAE

The section depicts the WQI of 15 different bottled water in UAE based on equation (4) (of subsection 2.3).

Figure 1: WQI for bottled water in UAE



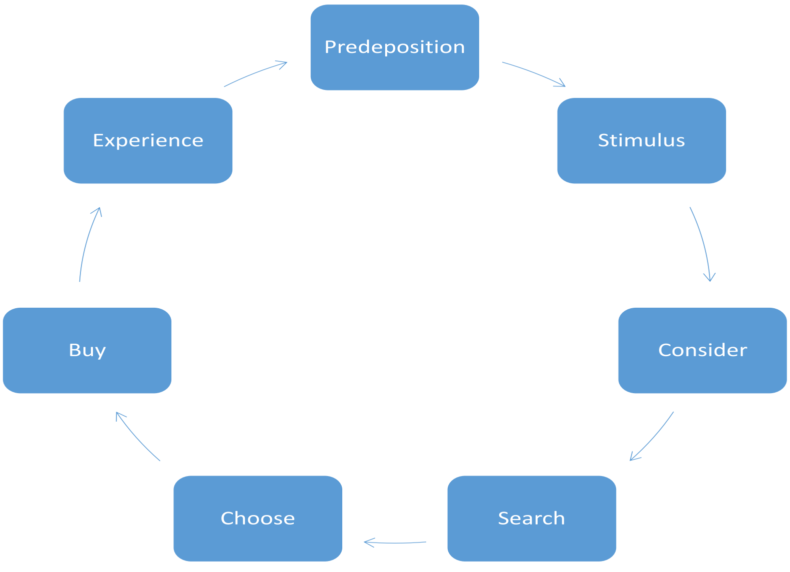
As indicated in Figure 1, the WQI for various bottled water varies significantly between different commercial available brands. The values of WQI drop significantly for some of the brands as they did not provided the values of the selected parameters. As consumers, we buy the bottled water without even recognizing how important these parameters are and what impact it can have, if neglected. Next section illustrates the analysis of awareness levels of consumers buying bottled water in UAE using mathematical assumptions.

3. INFORMATION SYSTEM FRAMEWORK FOR ANALYSIS OF AWARENESS LEVELS OF CONSUMERS BUYING BOTTLED WATER IN UAE

The investigation of awareness levels of consumers buying bottled water from various locations in UAE was an intimidating task. To analyze the awareness levels of consumer buying bottled water can be defined by using traditional Consumer Buying Behavior (CBB) model proposed by [6] is a set of linear transactions of the various stages of awareness levels of consumers before buying the bottled water. The model is no longer effective for current trends, wherein, the companies go about their business and interact with individuals. A tremendous amount of data is created, as it was observed during study that almost all these bottled companies use Social media, smartphones, and other consumer devices to advertise, promote and update the information with individuals [7]. As indicated by [8], "The era of marketing as we have known it is over, dead, kaput – and most marketers don't realize it". [8] Further clarifies that technology has given people many more options than they had in the past and has created a consumer awareness in which people around the world constantly use digital platforms to seek and share information to discuss consumer products.

Enduring to the study, [9] proposed the circular transaction model of CBB, termed as Consumer Buying Cycles (CBC). The model depicted in Figure 1 has 7 stages of CBC.

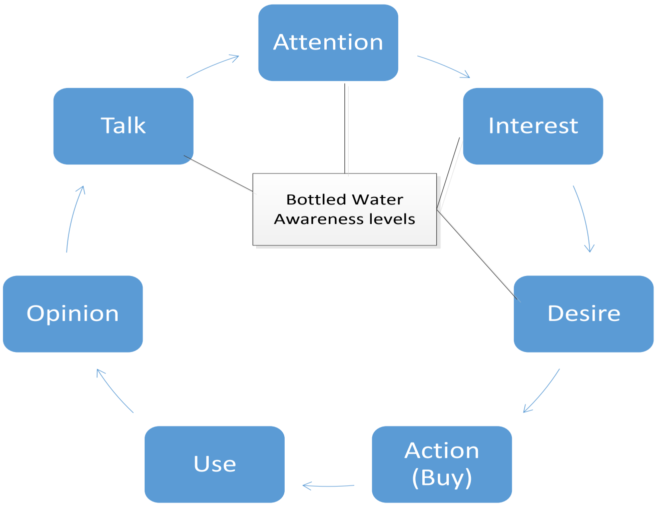
Figure 2: CBC proposed by Solomon [9]



The process of CBC as stated in Figure 2, designates that in the beginning state, the consumer has no plans of buying any bottled water until they identify a convinced stimulus. In the ensuing steps, the buyer contemplates the inevitability of the purchase, before moving to doing exploration to find the most apposite product in rapports of factors (price, place or review by other users), where awareness levels plays a vital role.

The model proposed for the study is an extension of [10] and clearly indicates that the influence of awareness level identification is larger in the beginning stages of the buying process. This can lead to getting users attention, raising interest for the bottled water or an actual desire to go and purchase the water bottle.

Figure 3: Information System enable CBC influenced by Awareness Strategies



The study presents the stochastic analysis on determination of average number of customers influenced by awareness strategies.

4 MATHEMATICAL ASSUMPTIONS TO DETERMINE THE CONSUMER AWARENESS OF BOTTLED WATER USING S-I-R MODEL

By using various consumer awareness methodologies, any new potential customers can be added to the market, and members of subpopulation can consent the market with the parameters portrayed in form of $f(\beta,\gamma,\alpha,\mu)$ as mentioned below:

- *β: Sharing rate , defines the rate at which the information is being shared.*
- *γ: Churn rate, rate at which the population depends on an updated information.*
- *α: Entering rate, rate at which the customers are entering the market.*
- *μ: Exiting rate, rate at which the customers are leaving the market.*

According to [11], there are three subdivisions of the total population of Market, N, as

- *S: S represents potential customers*
- *I: I represents current customers*
- *R: R represents former customers*

Mathematically,

$$N = S + I + R \quad (5)$$

By using various awareness techniques, the population of potential customers may become current customers or current customers becomes former customer clearly signifying that (S, I, R) are dynamic in nature.

It can be observed that the population entering the market becomes the part of "potential customer" population. The number of new potential customers joining the market at any instance of time is:

$$\alpha(S + I + R) \quad (6)$$

However, the population leaving the market can be part of any of the population and can be represented as $\mu S, \mu I$ and μR.

4.1 Usage of $S - I - R$ epidemiological model to determine the Number of potential customer

$S - I - R$ model is used to compute the theoretical number of people entering the market owing to consumer awareness in a closed population over time. There is constantly arrival of potential customers entering into the market. For this state, all the three parameters must be encompassed in the model, using the ensuing differential equations:

$$\frac{dS}{dt} = -\beta SI + \mu(N - S) = -\beta SI + \alpha(S + I + R) - \mu S \quad (7)$$

$$\frac{dI}{dt} = \beta SI - \gamma I - \mu I \quad (8)$$

$$\frac{dR}{dt} = \gamma I - \mu R \quad (9)$$

Smearing equations (7), (8) and (9), to estimate $\frac{dN}{dt}$,

$$\frac{dN}{dt} = \frac{d(S+I+R)}{dt} = \frac{dS}{dt} + \frac{dI}{dt} + \frac{dR}{dt} \quad (10)$$

Evaluating eq. (10), we observe

$$\frac{dN}{dt} = (\alpha - \mu)N \quad (11)$$

$$\int \frac{dN}{N} = (\alpha - \mu)\int dt$$

$$\therefore log\ N = (\alpha - \mu)t$$

$$N = e^{(\alpha-\mu)t} \quad (12)$$

Based on eq. (12), there can be three possibilities [12]:

1. Number of customer increases after awareness and market grows exponentially, $\alpha > \mu$
2. Consumer awareness had a neutral affect, $\alpha = \mu$
3. Consumer awareness had a negative effect, $\alpha < \mu$

The objective of the study is to ascertain the stochastic analysis of implications of consumer awareness amongst bottled water consumer's on the market expending case 1.

For estimation of probability of "n" customers from the complete population, N, certain assumptions are to be made, which includes,

1. Δt is a very small time in which any one of the situation, S, I *or* R occurs.
2. Case 1 needs to be maintained throughout the study.
3. α is entering rate of consumers into the market and μ is the exiting rate. Since, case 1 needs to be maintained, α should always be more than μ.

Probability of one customer entering the market=$\alpha\Delta t$
Probability of one customer exiting from the market=$\mu\Delta t$
Probability that no customer entering the market=$1-\alpha\Delta t$
Probability of no customer is exiting from the market=$1-\mu\Delta t$
The probability that there are n customers in the market at any given time t is represented as $P_n(t)$.

$$P(t+\Delta t) \begin{cases} P_{n(t)}(1-\alpha\Delta t)(1-\mu\Delta t) \\ P_{n+1(t)}\mu\Delta t \\ P_{n-1(t)}\alpha\Delta t \end{cases} \qquad (13)$$

or,

$$P(t+\Delta t) = P_n(t)(1-\alpha\Delta t)(1-\mu\Delta t) + P_{n+1}(t)\mu\Delta t + P_{n-1}(t)\alpha\Delta t \qquad (14)$$

$$\frac{P_0(t+\Delta t)-P_0(t)}{\Delta t} = -\alpha P_n(t) - \mu P_n(t) + \alpha P_{n-1}(t) + \mu P_{n+1}(t)$$

For the stable condition,

$$\lim_{\Delta t\to 0}\left\{\frac{P_n(t+\Delta t)-P_n(t)}{\Delta t}\right\} = \frac{d}{dt}\{P_n(t)\} = 0$$

So, eq. (11) becomes

$$P_{n-1}(t)\alpha\Delta t - (\alpha+\mu)P_n(t) + \mu P_{n+1}(t) = 0 \qquad (15)$$

Consider that there is no customer at time $(t+\Delta t)$ in the market, then,

$$P_0(t+\Delta t) = P_0(t)(1-\alpha\Delta t) + P_1(t)\mu\Delta t$$

$$\frac{P_n(t+\Delta t)-P_n(t)}{\Delta t} = -P_0(t)\alpha + P_1(t)\mu \qquad (16)$$

LHS of eq. (16) becomes

$$\lim_{\Delta t\to 0}\left\{\frac{P_n(t+\Delta t)-P_n(t)}{\Delta t}\right\} = \frac{d}{dt}\{P_0(t)\} = 0$$

Eq. (13) can be mentioned as

$$P_1(t) = (\alpha/\mu)P_0(t) \qquad (17)$$

For n^{th} values, the eq. (17) can be refurbished as

$$\sum_{i=0}^{n} P_i(t) = \left\{(\alpha/\mu)^0 + (\alpha/\mu)^1 + (\alpha/\mu)^2 + \ldots\ldots\ldots\ldots + (\alpha/\mu)^n\right\}P_0(t) \qquad (18)$$

Based on the limiting condition, when$n\to\infty$, and,$\alpha/\mu < 1$, LHS of eq. (18) becomes 1 and RHS of eq. (18) becomes $\left[\frac{1}{(1-\alpha/\mu)}\right]P_0(t)$

Rewriting eq. (18)

$$1 = \left[\frac{1}{(1-\alpha/\mu)}\right]P_0(t) \qquad (19)$$

Eq. (16) can be rewritten as

$$P_n(t) = (\alpha/\mu)^n(1-\alpha/\mu) \qquad (20)$$

Thus, based on eq. (20), the probability for the presence of "n" customers buying the bottled water based on consumer awareness campaign at any time "t" can be computed, provided the values of α

and μ are known. The equation for defining the average number of customers affected by awareness campaign for purchasing can be depicted as,

$$AvgCust_{(n)} = \sum_{n\to\infty}^{N} nP_n(t)$$
$$= \sum_{n\to\infty}^{N} (\alpha/\mu)^n (1 - \alpha/\mu)$$
$$= (1 - \alpha/\mu) \sum_{n\to\infty}^{N} (\alpha/\mu)^n$$
$$= (1 - \alpha/\mu)\left\{1.(\alpha/\mu)^1 + 2.(\alpha/\mu)^2 + 3.(\alpha/\mu)^3 + .\dots\dots\dots\dots + n.(\alpha/\mu)^n\right\}$$
$$AvgCust_{(n)} = \frac{(\alpha/\mu)}{(1-\alpha/\mu)} \quad (21)$$

Based on eq. (21), the average time required for customer for brand shifting after the awareness strategies is

$AvgWait(t) = \frac{1}{\mu}\left(\frac{\emptyset}{1-\emptyset}\right)$, where $\emptyset = \alpha/\mu$ (22)

5 OUTCOMES AND ANALYSIS

As indicated in Section 4, the section portrays the outcomes of the mathematical formulas developed. Table 4 depicts α and μ, based on which $AvgCust_{(n)}$ using specific bottled brands is calculated. Table1 also outlines the number of users using specific brands, in terms of percentage.

Table 4: Calculation of $AvgCust_{(n)}$

α	μ	NUMBER OF CUSTOMERS RESPONDED TO THE QUESTIONS ASKED	PERCENTAGE OF CUSTOMERS CHANGED DUE TO AWARENESS CAMPAIGN
66	100	7.33	11.11%
82	120	12.33	15.04%
99	140	19	19.19%
122	160	12.33	10.11%
131	180	89	67.94%
139	200	19	13.67%
144	220	21	14.58%
167	240	7.57	4.53%
181	260	20.67	11.42%
195	280	30.11	15.44%
212	300	26.27	12.39%

Table 5 illustrates the average brand shifting time each consumer takes to switch to different brand of bottled water. It must be noted that the output is purely based on the eq. (22) and defines the brand shifting time.

Table 5: Evaluation of Bottled water brand shift time

α	μ	BRAND SHIFTING TIME
66	100	0.073
82	120	0.103
99	140	0.136

122	160	0.077
131	180	0.494
139	200	0.095
144	220	0.095
167	240	0.032
181	260	0.079
195	280	0.108
212	300	0.088

CONCLUSION

Study concludes that awareness among respondents interviewed never taken composition as criteria for the purchase of drinking water bottle. Hence it becomes imperative to find out ways to devise strategies for composition awareness and there advantage therein for water bottle purchase, which leave scope for future researcher.

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