Innovative Solutions for Environmental Efficiency of Drinking Bottled Water Improvement

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Abstract. Nowadays water becomes most important resource and its value will grow in future each year. In this article the authors developed hierarchy model of the effectiveness of product distribution which takes into account both the interests of end users of mineral water and the interests of its producers. This model can be used to structure demand at points of sale and create valuable offers for consumers.

1. Introduction

Water is the most essential part of human activity. The human body, depending on age, consists of 60-75\% of water. If a person can survive without food for a long time (according to various sources, from 30 to 40 days of complete refusal of food), water is more essential – four days is enough for death. The average daily need for water, coming both in pure form and in the form of food consumed, is at least two liters, and with a non-renewable loss of five liters of water, a serious illness occurs. Thus, of all the known food products, water is the most important for people's life.

With a variety of different natural forms of water surrounding us, there is only one percent of its total volume (approximately 1.4 trillion m\textsuperscript{3}) on Earth available for consumption, and less than 0.1\% of this amount is actually consumed. The World Water Commission noted that at present, humankind spends an average of 1 liter of water, that is, 2,700 liters per day, to produce 1 calorie of food. According to the World Health Organization (WHO), with the planned growth rate of population of our planet in just five years, more than 3 billion people will need this resource. The current situation with the access to drinking water indicates that 2/3 of the limited resource suitable for water consumption is at the disposal of 10\% of the total number of states (23 countries out of more than 220). These statistics convincingly shows that already at the beginning of the XXI century, water, as a vital resource, is just as valuable and as insufficient as it was many centuries ago. So it is necessary to think about the rational use and renewal of such a precious water resource to avoid global humanitarian catastrophes and political conflicts.

The Russian Federation possesses about 25\% of the world reserves of ready-to-use fresh water with a population of just over 2\% of the world’s population. Especially it is fair for the population of the Siberian Federal District, on whose territory is located Lake Baikal, the largest natural reservoir. In addition to this unique natural resource, there are other sources of fresh water, both terrestrial and underground, at the territory of this region. These sources include drinking and mineral water intended
for medical purposes too. However, despite the own sources of this unique water resource, only 1/3 of the total turnover of bottled mineral water is consumed from regional sources, while about 3/4 of the population of such a Siberian region as Kuzbass does not use bottled water at all, preferring plumbing.

2. Environmental efficiency of drinking bottled water
Despite the same molecular formula, the structure and physicochemical properties of the water contained in living systems are significantly different from those of water that we use every day. A striking example of this is the fact that water inside animal and plant cells does not freeze at temperatures as low as –50 ° C and lower.

The most important property of water is its unusually high sensitivity to various physicochemical and energy-informational influences due to the presence of low-energy hydrogen bonds that can be rearranged under the action of various external influences that do not require large amounts of energy.

Thus, it can be argued that the impact on water is directly related to the impact on living systems, in particular, on the human body. For many centuries, these effects have been used to be applied in various occult, parapsychological and magical methods, such as the treatment of various diseases with “charged” water, getting rid of alcohol addiction, targeting damage, love spell, etc.

It can be an interesting theme for investigation to find out the reality of this kind of phenomena, its mechanism and connection with the structure and properties of water, as well as the effects on water and water systems of electromagnetic fields and other external factors not directly related to changes in the chemical composition of water and aqueous solutions. In addition, the problem of chemical water quality is still relevant, i.e. determining the content in it of various impurities that are harmful and beneficial to the human body, the search for more sophisticated methods of cleaning from pollution, as well as establishing the relationship between chemical and energy-information pollution.

Tap water is heavily contaminated with pesticides, herbicides, nitrates, nitrites, heavy metals, polycyclic aromatic hydrocarbons, and maximum permissible values are established for the content of these substances, which should not be exceeded. Substances used for biological and chemical cleaning should, if possible, be removed from the water by the water supplying enterprise. And although these chemicals are filtered out, their traces (information) remain in the water, which negatively affect the body, from which it becomes clear to everyone that all water filters are in themselves insufficient, as they are able to remove only harmful chemical solids, but not negative information, which is carried by the macromolecules of water themselves.

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Any system whose order level is above the minimum acceptable 60% begins self-regulatory maintenance of ordered interactions. The higher is content of clusters in water, the more ordered its structure, and the more it is able to reproduce itself, which is observed in living systems. This indicates that the water of the human body can play a system-forming role, on the one hand, and a regulatory role, on the other.

Source water can be fresh or mineralized. In the first case we are talking about springs and in the second - about the source of mineral waters. The term "natural spring water" means that the composition of the minerals in this water has not undergone any physical and chemical changes. However, it can be filtered or processed in any other way.

A spring is a small stream of water, available directly from the bowels of the earth. Springs, as the outlets of groundwater, are unique natural reservoirs. They are of great importance in feeding other surface water objects, maintaining water balance and preserving the stability of the surrounding
biocenoses. Some Russian rivers and reservoirs are generated by just such underground sources. They are powered by deeper aquifers (over 10–20 m), where pollutants from the surface practically do not penetrate. According to the hydrochemical features of spring water, the state of groundwater in the region can be analyzed.

Springs are strategic objects of nature. In the event of an emergency, they can act as the only sources of drinking water for the population. Many legends and customs of the local population are associated with springs. The water of some springs is considered by the local population to be holy, healing, used in the treatment of various diseases. On some springs chapels were built, which are of historical and cultural value. Spring water comes to us in its original, natural in its hydrochemical composition. In addition, it is lively, mobile. Spring water from an environmentally clean, proven source does not need to be cleaned: getting from the depths to the surface of the Earth and passing through sand and gravel, it undergoes a natural and almost perfect purification. It is believed that spring water has healing properties.

Unlike all other types of water spring water doesn’t require purification using various technologies (adsorption, reverse osmosis, ion exchange resins) that change the physico-chemical composition and the natural structure of water. This is due to the fact that various substances present in the source water at elevated concentrations require significant transformations to achieve water compliance with SanPin standards for drinking water. The nature of spring water is the same as of artesian water, as it comes from an underground aquifer or basin. To comply with the term "spring", water must flow to the surface under the influence of natural forces.

Bottled spring and mineral water are widely popular in large a city, that’s why its sales volumes have increased significantly nowadays. Springs and wells from which this water is taken should be located away from urban underground utilities, landfills and other sources of contamination, and the chemical composition of water should be regularly monitored by sanitary services. Moreover label of a bottle of water, called spring, must necessarily indicates the geographical location of the spring.

The use of spring water is the best way out in modern conditions. By nature, pure, balanced in physico-chemical composition, natural spring water, gives energy to those who drink it. In Russia, the number of springs is incalculable; they differ by the quality and composition of the water. Spring waters have healing properties, they are fresh and pleasant to taste. But springs as well as artesian wells are subject to pollution. Nowadays, it is impossible to guarantee the constant quality of spring water, as it depends not only on seasonal circumstances (rainfall, floods, groundwater), but also on emissions from nearby industrial enterprises.

It is difficult to imagine a clean spring in the center of the city, with a poor environment and high gas content. The general sanitary and hygienic characteristics of spring runoff in urban areas are not suitable for drinking. Therefore, high-quality spring water can only be in a spring located in a forested, forested area where there are no industrial facilities; no agricultural work is carried out, away from highways and large settlements. Only such spring water is suitable for drinking and good for health. Even 30 - 40 years ago, the springs were quite clean and "drinking". But with the beginning of mass construction, the soil began to become polluted, and with it the water.

In addition to springs, ordinary fresh water is obtained from wells and artesian wells. The wells are actually used only in rural areas, since the hole with a depth of 5-10 m is not capable of providing a large water outlet - for this it is necessary to drill wells in 20-150 m, depending on the depth of the groundwater. Wells feed on underground waters and can provide water consumption up to 100-150 l / h (in rare cases - up to 500 l / h). They are very vulnerable in terms of pollution: everything that enters the soil — nitrates, nitrites, surfactants, pesticides and heavy metals — can end up in well water.

Deep waters are better protected from various industrial and bacterial contaminants. For drilling, special installations are used, then steel pipes are lowered into the well, a powerful pump is immersed, through which the pipeline is brought to the surface. There are two aquifers: sandy lies at a depth of 15-40 m and is separated from the top layer of soil by clayey layers, which protect it from pollution, and at a depth of 30-230 m and more limestone aquifers, so-called artesian, are located. The composition of artesian water depends on the depth of their occurrence. Such water may have
increased stiffness and contain bacteria and organic matter. In addition, contamination from higher aquifers can leak into the artesian water due to poor pipe joints in the wells. Typically, this water must be filtered and purified, which is carried out using industrial and domestic wastewater treatment systems.

Siberia has a large variety of mineral waters of different composition. Cold and thermal carbonic waters with a high content of silicon, some balneologically active micro- and biogenic elements, dissolved organic matter, and optimal radioactivity are concentrated here. Nitrogen hydrotherms are widely distributed in the Baikal rift zone. This is mainly low-mineralized water, sulphate-sodium, sulphate-bicarbonate-sodium composition, with a high content of fluorine, silicic acid, slightly radioactive. Low-mineralized mineral water contains dissolved organic matter, which is a valuable component when used in balneology. In the Russian stores, as well as in pharmacies, a wide range of natural mineral waters is presented.

3. Mineral water hierarchy systematization

We have developed a scheme for systematization of balneological properties according to a hierarchical principle, from individual indicators to source of mineral waters type (figure).

Among the classes of sources, there are three, which give drinking water of three fundamentally different classes, of which the most physiologically valuable is the underground key, since when water rises through a borehole, it is possible to change its natural information and energy state. With deep mining from the terrestrial reservoir, mineral water has the lowest physiological value in terms of the absence of its contact with underground minerals and the free water exchange of the reservoir with precipitation.

A subclass of bottled drinking water determines its balneological effectiveness with regard to the minimum limits of the presence of balneology active components. This hierarchical level assumes the determining choice of the desired effect on the human body.

The level of the type and subspecies of bottled drinking water suggests a choice based on the mass concentration of mineral substances, which determines both balneological effectiveness and taste of mineral waters: medicinal, medicinal-dining, dining.

The level of types of bottled drinking water involves taking into account their differences in anion-cation composition, based on the formula of M.G. Kurlov, allow to choose the most effective alternative for balneological indicators

The level of varieties of bottled drinking water suggests the choice of the degree of their saturation with endogenous or exogenous carbon dioxide or other gas, and at the level of choice of the product article, the type and volume of packages and trade mark are determined by alternative options.

To assess the environmental performance of all processes accompanying the flow of mineral water from the source to the final consumer in the Russian regions (Ec), a complex mathematical model (formula 1) has been proposed.

\[ Ec = \mathcal{E}_d + \mathcal{E}_p + \mathcal{E}_l + \mathcal{E}_t + \mathcal{E}_f \]  

with: \( \mathcal{E}_d \), \( \mathcal{E}_p \), \( \mathcal{E}_l \), \( \mathcal{E}_t \), \( \mathcal{E}_f \) - the efficiency of production, processing, logistics, commodity circulation and the functional action of mineral waters, respectively.

Thus the definition of \( Ec \) will be possible when performing additive differentiated levels of efficiency of all processes used for the purpose of product distribution (formulas 2-6):

\[
\begin{align*}
\mathcal{E}_d &= \mathcal{E}_{d1} + BP + \mathcal{E}_{f1} \\
\mathcal{E}_p &= \mathcal{E}_{p1} + \mathcal{E}_{p2} + \mathcal{E}_{f2} \\
\mathcal{E}_l &= \mathcal{E}_{l1} + \mathcal{E}_{l2} + \mathcal{E}_{f3} \\
\mathcal{E}_t &= \mathcal{E}_{t1} + \mathcal{E}_{t2} + \mathcal{E}_{f4} \\
\mathcal{E}_f &= \mathcal{E}_{f5} + \mathcal{E}_{f6} + \mathcal{E}_{f7} + \mathcal{E}_{f8} \\
\end{align*}
\]  

with \( \mathcal{E}_{d1} \), \( BP \), \( \mathcal{E}_{f1} \) - energy costs for water extraction, renewability of water resources, costs of environmental measures, respectively;
Энп, СК, РУ, Экп - energy costs for water processing, preservation of its quality, resources spent on its packaging and environmental safety, respectively;

Эдп, Идп, Идст - energy costs for the delivery of water, the costs of delivery and storage, the preservation of its quality, respectively;

Ф, Ε, Π, Ξ - physical and economic parameters, as well as the psychological aspects of the sales offer, perceived customer value, respectively.

КО, ЭИС, ЭС, СС, КП - the quality of water treatment, its energy-informational state, the emotional and symbolic properties of the finished product and its competitive advantages, respectively.

This model of the effectiveness of product distribution is complex in its essence and multi-level in content. It takes into account both the interests of end users of mineral water, and the interests of its producers, as well as society in general.

Application of the developed model is possible when the conditions of additivity of its essential components, characterizing the efficiency of production, processing, logistics, commodity circulation and the functional action of mineral waters. The correctness of its calculation is provided by the methodology for calculating both individual and complex performance indicators, which, in turn, implies multilevel assessment criteria, the hierarchy of their significance, and correctness of mathematical calculations and expert evaluation of their results.

One of the heuristic methods that allows you to quickly and fairly correctly determine the efficiency of distribution of mineral waters in the implementation of all practical recommendations given below is the method of recalculating all energy consumption (production, logistics, storage, sale) to the consumption of a single energy source, such as WTI oil, most common in the practice of product distribution.

Calculations of the values of Эдп, Эп, Эл, Этп by this criterion allows to heuristically estimate the difference in the effectiveness of these indicators using the developed recommendations and without them using the formula (7):

\[ \text{Эдп}_1 = 0.25 \frac{L_{WTI}}{L_{мв}} \]  

with \( L_{WTI} \) - energy volume; \( L_{мв} \) - volume of mineral water.

If the cost of 1 L_{WTI} is 28 rubles, the delivery of 1 L_{мв} with ignoring the practical recommendations suggested below can be estimated at an equivalent amount of money. In the scale of the Russian mineral water turnover, equal to 3.8 billion liters per year, of which 1.9 billion liters are delivered from remote sources, the efficiency of taking into account the factors of distribution in accordance with the model developed by us can be estimated at 1,778.5 million rubles.

Thus, the application of the developed mathematical model in the practice of product distribution will allow obtaining a significant national economic effect in the form of saved energy and natural resources. According to our estimates, the use of this scientific development will bring in Russia an annual economic effect in the amount of 1,778.5 million rubles.

4. Results adaptation

Based on the studies conducted on the study of the factors that form the balneological properties of mineral waters, we can draw the following conclusions:

1) Based on the study of balneological factors of mineral waters and comparison with the declared values, it was established that Russian producers provide a wide range of deviations in the concentrations of key components taking into account their possible losses during transportation and storage. It was proposed to reliably inform consumers to limit the range of deviations only to the natural seasonal variations of these components.

2) To improve the efficiency of distribution of mineral waters, a map-scheme of their balneological properties was developed in the form of a hierarchically organized system from single indicators to a class of sources.
3) A mathematical model has been developed for the efficiency of distribution of mineral waters, taking into account the maximization of their consumer value and the parity of interests of the participants in the logistics chain from source to consumer.

4) Was proposed method for calculating the efficiency of the distribution of mineral waters through an integrated assessment of raw material consumption and energy resources expended, which, when using the developed model for the Russian regional markets, is approximately 1,778.5 million rubles per year.

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