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Review Article

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Monitoring Bottled Mineral Water Brands

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Abstract Surface water in ponds, rivers, …etc., is the most important fresh water source found on the Earth. Whereas spring groundwater results from that water leaked and retained into the ground, and is more safe to contamination than surface water sources, but still contains high amounts of certain contaminants from industrial waste, inoperative septic systems, underground gas or chemical tanks. Both categories are physical-chemical treated to follow drinking water regulations regarding chemical, biological and radiological aspects. As water becomes more sparse, its management grows immensely. Artesian water is the same as underground spring or mineral water but differs in how it gets to the surface. An artesian well occurs when there is adequate pressure in the aquifer to force the water towards the surface. Spring waters are bottled off-site and their mineral content varies considerably, bottled mineral water contains at least 250 ppm of dissolved solids, including minerals and traces elements shown on their labels, its plastic materials should be accurately chosen and stored to avoid health risks.

Keywords Groundwater, Grand Ethiopian Renaissance Dam (GERD), water standards, Endocrine disruption

Introduction

Bottled water companies depend on unreasonable recommend efforts to sell products on the inaccurate belief that pre-packaged water is cleaner and safer than tap water. The taste of the water depends on its treatment, the source, and its natural mineral content [1]. These minerals can be added artificially or naturally be in the water. There are three main types of bottled water; natural mineral water, spring water and bottled drinking water. The natural mineral water originates in a ground water table and flows over rocks to appear at egresses, before it's collected and bottled at the spring source, but it doesn't undergo the treatment in the same way as spring water.

Effervescent mineral water contains naturally occurring carbonation and minerals. Since it's bottled directly from a natural source, it tends to be expensive and has less effervescence than other carbonated waters. Un-natural carbonated water, sparkling water or soda water mean water into which carbon dioxide has been dissolved as all fizzy waters. Within this category, there are seltzer and club soda. While seltzer contains no added flavorings, club soda contains additives such as table salt, sodium or potassium bicarbonate to maintain a slightly salty flavor. Carbonated water increases bowel bloating syndrome due to the release of carbon dioxide in the digestive tract, helps with constipation among people suffering a stroke [2], but It doesn't affect gastroesophageal reflux disease [3].

Un-carbonated bottled waters have a large bacterial community after storage. Researchers found that bacterial growth was due to oxygenation of the water during the bottling process, the increased bottle surface area, and trace nutrients arising from the bottle such as carbon, or feeding of bacteria on the products of lysis of autotrophs. Adequate water intake permits the body to excrete wastes and helps to digest soluble fiber and benefits bowel health.

Freshwater Abundance in Egypt

The traditional water resources in Egypt are the Nile river, groundwater aquifers, rainfall and flash floods. More than 96% of Egypt freshwater resources are supplied by the Nile River which used in drinking, agriculture, electricity generation from the High Dam ...etc [4]. Although there is plenty of fresh consumable drinking water in springs, lakes, rivers, and streams, yet, these sources supply a negligible amount of fresh water.

Rainwear is an important source of fresh water. Rainwater originates from evaporation into the Earth's atmosphere and is turned into rain. This rain freshwater is provided throughout the world as drinking water and irrigation source. Collecting rainwater technology has been used anciently in many country-sides to make this supply of fresh water available. Groundwater is also great source of fresh water but may be unfit for human consumption. However, a proportion of groundwater is fresh and can be desalinated and clarified in order to provide satisfactory drinking water for populations. Many hydrogeological studies are used to prove that this water originates from the underground source and is protected from pollution to some extent. In the bottled water industry, water will usually be accessed by a borehole to capture it. Spring water must meet certain hygiene standards and may be further treated so they meet pollution regulations. However, it doesn't have to undergo the same rigorous regulatory process as natural mineral water. Since 2005, Egypt is classified as a water scarce country [5]. Hurghada and other cities on the red sea coast are supplied with water from the Nile River by pipelines. Management plans are predicted to manage freshwater resources decrease due to Grand Ethiopian Renaissance Dam (GERD) risks and to estimate its influence on the Aswan High Dam during working [6-9]. Researchers pointed to maximum permitted depletion of Egypt's water portion should not be more than 5–15 %. Moreover, it is believed that the gradual deficiency percentage of the groundwater according to GERD is 33% yearly.

Controlling the Negative Impact of (GERD) on Egypt

The decreased Nile water velocities will result in increased sedimentation process, which affects drinking water properties, the efficiency of pump stations, hydropower deficiency [10], secured navigation, and the increased evaporation rates will be reflected on Nile water salinity. Besides, while most sewage terminated to the river in Lower Egypt, northern Egypt Lakes are also influenced by drainage of spoiled water. Nile water pollutants come from industrial wastewater, oil pollution, municipal wastewater, agricultural drainage [11, 12].

Donating an alternative water source is a suggested strategy to reduce the possible damage and emergency plans facing the shortage of groundwater stock in Egypt. One of this plan is drilling water wells for groundwater that exist in western desert and Sinai in aquifers that are mostly deep and non-renewable. On the contrast, the Nile aquifer, which lies below cultivated land in the valley and Delta reservoirs is shallow, renewable and its water quality isn't good as the deep groundwater in the desert. This aquifer is recharged only by drainage losses from the Nile, the irrigation canals and leach losses from irrigated lands. Hence, its yield must not be added to Egypt's total water resources, but it is considered as the Nile river-reservoir system with a huge capacity. Inexpensiveness, continuity, and rechargeable rates are the most important aspects of the aquifers dependent strategy. These rates rely on its adjacency to external water sources, and time water takes to refill it due to soil and sand firmness round it. In the case of confined aquifers, replenishment can take a longer time, as its sources of water are underground systems that have to travel long distances. Unfortunately, many deep underground confined aquifers have long since been cut off from replenishment sources; once accessed as a water supply, they will eventually be consumed. However, some confined aquifers are fed by underground tributaries where they are locked in impermeable rock, and protected from the contaminants. Unconfined aquifers formed at a quicker rate compared to confined aquifers [13]. This is because their near presence to water sources from rain, streams or rivers. But they have a greater exposure to contamination from their sources. As water that seeps into unconfined aquifers may also originate from canals and drains. An aquifer is a porous and permeable layer of rock through which water can easily move. For example, limestone, sandstone or conglomerate which can contain or transmit groundwater. When water passes through an aquifer, it naturally filters out impurities. Canals are unsafe because of pesticide poisoning or the released toxic industrial chemicals, as a result, these aquifers may be exposed to a higher risk of polluting from bacteria and decaying organic material. Rational water use in Egypt via the reuse of low-quality water drainage and wastewater treatment [14] is another water deficiency facing protocol.

Protection of Crude Water Sources

Physico-chemical analyses must be done to show that water comes from a single spring is free from harmful organisms or injurious substances and its mineral content is stable within the period of extraction. Protecting wells from contamination and its processing improvement to comply with good manufacturing practices (GMP) by modifications in design help facing natural disasters or industrial accidents, e.g. a flexible plastic pipe is more resistant than the rigid pipe to earth quivering and, raising the panel of a dug well with outward- inclined concrete strip around it. In order to prevent deep and surface water from mixing, catchment at natural springs is increasingly avoided to support drilling. When abusing catch work is abandoned, some technical requirements must be satisfied to prevent the deposit's water from filling with bentonite or cement slurry but if the surface or groundwater could be affected by toxic threat, it is probably better to avoid the water source. Wells near rivers can be contaminated and filled with sand during unusual flash flooding. Digging boreholes are particularly vulnerable during wars since toxic materials can be discarded in wells, and the pumps deliberately damage. Shallow wells in areas with a high water-table are more liable to contamination from drowning than are deep boreholes [15, 16].

Surveillance and Quality Control

Environmental health and trading standards are consulted at every catchment stage to ensure regulatory acceptance. Given that monitoring must be defined on a case-by-case basis, no standard schedule can be established but risk management, through the organization of health-based targets, catchment-to-consumer water safety plans, and independent surveillance, i.e. they must comply with standards according to their brand [17, 18]. Bottled drinking water must comply with the standard for natural mineral water codex STAN 108-1981 and because is it classed as a food, must comply with the fourth edition of the World Health Organization's (WHO) [19, 21]. Flavored water is classed as a soft drink, not water, and there are no specific regulations regarding the composition of soft drinks.

Biological Aspects

The presence of signal organisms indicates water contamination by fecal matter and hence their absence denotes water safety, in general. Although coliform organisms may not always be directly related to the presence of fecal contamination or pathogens in drinking water, the coliform test is still useful to observe the microbial quality of drinking water [22-24]. Researchers committed that only *E. coli* are considered as a specific and definitive indicator of fecal pollution of water; since the more general test for Fecal Coliforms (FC) also detects thermo-tolerant non-fecal coliform bacteria as none of the microbial indicators of fecal contamination (TC, FC, and enterococci) were detected in bottled water. *Pseudomonas aeruginosa* has been prescribed as a mean of monitoring the sanitary quality of drinking water. Contamination may result from microbial colonization on the bottling plant equipment; rubber seals, washers or even purify soap that may all provide nutrients for these organisms. It can grow in low-nutrient water such as deionized and distilled mineral water and reach 104 CFU/ml thus increasing the public health risks. The presence of *P. aeruginosa* may restrain standard coliform enumeration procedures and can degenerate, watercolor, turbidity, and taste. Al Masry Al Yom newspaper 2012 stated that portion of mineral water in Egypt is unsuitable for human use because it is catched from wells containing toxins or less than 200 meters deep, this explain that water of the well is too close to sanitation water to be used for safe drinking. [25] stated that the three bottled mineral water agencies, Nestle, Aquafina, and Baraka had produced bottled water that was unfit for human consumption, and 38.3% of the examined bottled water samples in Alexandria were bacteriologically unsatisfactory and failed to meet the Egyptian standards [26, 27]. Investigations on *Staphylococcus aureus* indicate poor hygienic practices during the bottling process as staphylococci are part of the symbiosis of skin flora [28, 29].

Radiological Aspects

Presence of combined radium-226/-228, gross alpha particle radioactivity, beta particle and photon radioactivity suggests non-compliance with GMP regulations, it is used to assess the quality of bottled water and public drinking water. High-performance aeration as a simple available technique to decrease radon concentrations in drinking-water, adsorption via granular activated carbon, with or without ion exchange, can also achieve high radon removal efficiencies [30]. EPA published the legal level for uranium in bottled water is 30 mg/L water as a maximum contaminant level. The long-term exposure to uranium in drinking water may result in increased risk of cancer. The analytical methods used for determining compliance with the quality standard for uranium in bottled water Method 7500-U B.

Chemical Aspects

Chlorine treatment by-products contaminants such as Trihalomethanes (THMs) are formed in drinking water due to chlorination of organic matter present naturally in raw water supplies:Trihalomethanes (bromoform, bromodichloromethane, dibromochloromethane, chloroform. They are classified as Group B carcinogens. Certain regulations limit the concentration of these chemicals added together (total trihalomethane or TTHM levels) to 80 ug/l [31].

Water Treatments

Reduction of suspended solids and dissolved ions in surface water by coagulating small particles in the raw water using poly-electrolyte at higher pH, then the settled down coagulated suspended matter passed through a tube settler where clearer water flows up. The coagulated suspended matter is extracted as a thick slurry. Clearwater is then treated in filters for more reduction of suspended matter to reach 5 ppm. To achieve the highest quality standards pure water, skillful designing comprising ion exchange, demineralization electro de-ionization plant, and ultra-fine filtration, steam generators were applied. Filtered sparkling water machines work to remove impurities present in tap water while keeping the healthy minerals, and the taste characterizing filtered water. Application of aquatic solutions offer cost-effective raw water treatment solutions.   Water is also disinfected using different ozone dosage, which kills most microbes. It provides a residual disinfection for a limited time without residual taste. The time chlorine and ozone remains active in water depends on many factors, including temperature. Refrigeration has a significant effect on the biological quality of the purchased bottle as evidence of contamination at the source or during the bottling process [32].

Although some microorganisms, are insignificant on public health, yet it may grow to higher levels in bottled water. Inreverse osmosis purification technique, water is forced under pressure to pass through a membrane, leaving contaminants behind to exclude microbes, minerals, turbidity, organic and inorganic chemicals. In the ultraviolet process (UV) water is passed through UV light, and distilling water kills most microbes. Steamed distilled water is re-condensed and bottled water's natural minerals, giving its taste to assess its quality and comparing with the Egyptian standards for natural drinking bottled water No.1589/2005 in order to comply the safety of bottled water for human consumption. In absence of ultraviolet irradiation treatment or others, bacterial multiplication may commence 1-2 days after bottling and can continue for 1-3 weeks, resulting in a population of 105- 106 CFU/ml [33].

Guiding Principles of Bottled Water Labeling

Labeled bottled water must provide consumers with information about their specific brand according to general standard for the labeling of prepackaged foods (CODEX STAN 1-1985, very detailed information about the nutrition profile of the water; mineral and trace element contents., etc. Following the European regulation, there are mandatory and optional indications on labels; date, the storage and use conditions, the name and address of the manufacturer and/or packager, type and grade of the plastic resin.…etc. With the information currently required to be on the bottled water label, consumers are able to have certain information to differentiate between bottled waters and a mean to obtain more information about their specific brand of bottled water [34,35].

Packaging Materials and Health Risks Caveat

The quality of bottled water can also markedly vary among labels according to mandatory and optional indications; source, treatment technology, shelf-life and the used plastic. Bottled water when in distribution or storage conditions for several weeks adversely affect its quality [36]. As indicated by the bottle label plastics, the polyethylene terephthalate (PET) made bottle is sterilized and automatically filled and it is much preferable to Polyvinyl Chloride PVC because it is brighter, very translucent, a break –resistant, 20% lighter than PVC that enables to reduce resin weight needed to make a bottle andwhen pressed, wastes volume is smaller. However, when PET is burnt, synthetic carcinogens are released regardless the type of incinerator used. PET natural mineral waters plastics leach antimony, a metalloid element that is a classified as a carcinogen, causes endocrine disordering reproductive functions, early adolescence [37-38]. In small doses, antimony cause dizziness and depression, while larger doses, cause nausea, vomiting, and death. The studies showed that the amounts of antimony levels almost doubled when the bottles were stored for three months but there are concerns about the cumulative effect of small doses [39]. Phthalates are chemicals that have been shown to leach also into bottled water over time. Recent research has related phthalates to an increased risk of high blood pressure and diabetes in children and adolescents, a higher risk of miscarriage, and spontaneous abortion. Exposure to environmental chemicals such as bisphenol A (BPA) and phthalates may play a role in the development of child behavioral problems [40], besides, BPA that could leach into food and drinks. When PET recycled, it can be turned into polyester carpets, fibers for the textile and clothing industry, plastic films, eggs boxes, and new PET bottles [41,42]. Accordingly, such bottles are safe for one-time use, but their reuse when they aren't in perfect condition should be avoided because studies indicate their DEHP leaching, another human carcinogen. The particular, responsibility, of manufacturers, are clearly defined in regulations EC no. 852/2004 and EC 882/2004 on food processing industries. The most bottled water companies label showed that their water is proper for 1 to 2 years of storage time at room temperature [43].

Safety of the Plastic Grades in Water Bottles

Most types of plastic bottles are safe to reuse at least a few times if properly washed with hot soapy water, but increases the chance that chemicals will leak out of the tiny cracks and crevices that develop over time. Recent studies regarding Lexan (plastic #7) bottles cause serious health hazard on reusing them and plastic #6 (polystyrene/PS), has been shown to leach styrene, another probable human carcinogen, into food and drinks must be avoided, so, millions of plastic bottles end up in landfills. Bottles produced from safer high-density polyethylene HDPE (plastic #2), low-density polyethylene (LDPE, plastic #4) polypropylene (PP, or plastic #5), or aluminum bottles are sold in many natural foods and natural product markets. Stainless steel water bottles are also safe and can be reused repeatedly and eventually recycled.

High numbers of heterotrophic bacteria in bottled water might come from the nonsterile plastic bottles arrived at the plant in cardboard cartons and are shipped without caps, thus the interiors are exposed to airborne contamination and the presence of foreign matter or contaminated equipment during bottling. This suggests that the bottled water may be subjected to contamination, not only from the containers but also from the physical surroundings and thepeople who come in contact with any part of the bottling operation [44].

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