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Minerals in drinking water available in Bangkok, Nakhon Nayok, and Chachoengsao

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ABSTRACT: In this study, drinking water from various sources in Bangkok and two other provinces in Thailand was collected, and its physical properties and mineral content were determined. Water from canals and dug wells contained diverse components making it turbid and coloured. Artesian water from the same province as canal and dug well water had similar mineral content, indicating that pollutants could spread thoroughly. The amount of iron detected in tap water varied from house to house, depending on its plumbing system since it came from corroded aged metal pipelines. The purity and mineral content of some bottled purified and mineral water were identical to that of the tap water. Furthermore, there was phosphate contamination in bottled water, probably from the bottle washing powder. Both local and imported bottled mineral water contained lower amounts of calcium and magnesium than expected, thus they might not be an effective mineral supplement. The high sodium content of sports drinks could make them harmful to health. The perception that bottled water is healthier than tap water should be reconsidered.

KEYWORDS: bottled, calcium, iron, magnesium, phosphate, sodium

INTRODUCTION

Drinking water is one of the essential needs for life. Naturally, plain water comes from either a natural surface or a ground source. A natural water source is rain, which in some areas is stored for drinking. Currently, in many parts of the world, drinking water comes from a public water system and commercial bottles. A survey has shown that people typically chose their drinking water based on their beliefs, perception, and prior experiences[1]. Due to limited information available, bottled water manufacturers use advertising to persuade their customers to buy their product as a healthy choice[2]. Furthermore, the bottled mineral water is promoted as a mineral supplement. Consequently, the demand for bottled water has consistently increased, followed by a growing concern about fraudulent claims regarding the water quality[2–4].

There are various minerals in water; some have health benefits, but others pose health risks. Calcium and magnesium benefit health in preventing several diseases including cardiovascular diseases[5–7]. Sodium is found considerably in daily foods and because of its undesired hypertensinogenic effect, its presence in drinking water is considered a health risk[8–10]. Iron in drinking water results in disagreeable taste and rusty colour[11]. Phosphate in water is responsible for eutrophication as well, which poses significant environmental problems to water resources[12–14]. Phosphate, in phosphorus compounds, is found in fertilizers, pesticides, washing powders, or plastics. Thus phosphate in water comes from contamination of household or industrial wastewater and agricultural runoff. Information about the amounts of these minerals in drinking water can help consumers to choose water with properties that suits their needs and with a reasonable price.

In this study, the amounts of minerals in various kinds of drinking water from different locations in Thailand were determined. The aim was to compare physical appearances and mineral contents among drinking water from different sources available in three different provinces of Thailand.

MATERIALS AND METHODS

Water sample

Water samples were collected from the canals and dug wells in rural areas of Nakhon Nayok and Chachoengsao provinces during a rainy season. Samples of artesian water and rain were collected from these rural areas. Tap water samples were

collected from urban areas in these provinces and from two different locations in Bangkok. Bottled water; three local brands of purified water, three local brands, and two imported European brands of mineral water, and two local brands of sport drink were purchased from a convenience store.

Analysis

Physical appearances: pH, colour, turbidity, total dissolved solid (TDS) and hardness of water were investigated by APHA recommended standard procedures[17]. Electrolyte analyses: sodium, potassium, chloride, bicarbonate, calcium, and phosphate were analysed by VITROS 950 chemistry analyser (Ortho Clinical Diagnostics, Inc., Johnson & Johnson, Rochester, NY). Iron and magnesium were analysed by BioSystems reagent & instruments (BioSystems, S.A., Barcelona, Spain).

RESULTS

The physical properties of water samples are shown in Table 1, and their mineral contents in Table 2. Dug well and canal water had a mild to moderate stinky odour and brackish taste with fairly amounts of sediment. The artesian water was mild yellowish brown and brackish. Except for local brand #1, all bottled mineral water was brackish. Both sport drinks were amber yellow, fragrant, and salty sweet.

DISCUSSION

Nowadays, drinking water is supplied in various forms. Surface water in a canal or a dug well is still consumed in some areas including rural and urban areas of Thailand. The water exposed to surrounding environment has unpleasant physical properties and diverse compositions derived from the geogenic, anthropogenic, and marine origins[18,19]. In this study, the canal and dug well water was coloured which is partly related to the iron contents. Nevertheless, its colour and TDS values indicate that there were soluble inorganic and organic salts or compounds dissolved in the water. Because the water has been exposed to agricultural fields and residential areas, it was unavoidably contaminated by pollutants and waste products. Sodium and chloride were detected in water from Chachoengsao province. Because the natural water sources in this province are linked to the gulf of Thailand via Bang Pakong River, NaCl in the water from this province results from tidal flushing of sea water[20]. Phosphate was detected in this water, which might have derived from chemical fertilizers and pesti-

Table 1 The physical properties of water.

Source of water	pH	Colour unit	Turbidity NTU	TDS (mg/l)	Hardness (mg/l)
Chachoengsao dug well	7.28	35	45	420	259
Nakhon Nayok dug well	7.21	45	50	340	161
Chachoengsao canal	7.16	30	55	410	328
Nakhon Nayok canal	7.22	25	50	350	60
Chachoengsao artesian water	7.36	15	2	380	230
Nakhon Nayok artesian water	7.32	25	2	270	53
Chachoengsao rain water	6.64	10	1	170	66
Nakhon Nayok rain water	6.81	40	1	90	63
Chachoengsao tap water	6.75	15	0	70	66
Nakhon Nayok tap water	6.82	1	0	50	31
Bangkok tap water #1	6.66	10	0	80	102
Bangkok tap water #2	7.04	1	0	80	77
Bottled purified water #1	6.87	10	0	80	26
Bottled purified water #2	7.11	10	0	110	118
Bottled purified water #3	6.74	1	0	50	26
Local bottled mineral water #1	6.82	10	0	110	26
Local bottled mineral water #2	6.75	1	1	150	210
Local bottled mineral water #3	6.78	15	1	180	122
Imported bottled mineral water #1	6.53	25	1	230	350
Imported mineral water #2	7.02	10	1	210	252
Sport drink #1	6.82	65	10	670	26
Sport drink #2	6.89	60	10	590	26
Thailand Tap Water Standard[†]	6.5–8.5	15	5	500	300

[†] in agreement with WHO 2011[15,16].

Table 2 The mineral concentrations of water.

Source of water	Concentration (mg/l)							
	Na^+	K^+	Cl^-	HCO_3^-	Mg^{2+}	Ca^{2+}	PO_4^-	Fe^{3+}
Chachoengsao dug well	253	20	603	305	29	56	ND	0.28
Nakhon Nayok dug well	ND	ND	177	ND	13	43	8	0.54
Chachoengsao canal	207	31	461	305	47	54	7	0.11
Nakhon Nayok canal	ND	ND	ND	ND	6	14	5	0.23
Chachoengsao artesian water	276	20	638	366	22	56	ND	0.18
Nakhon Nayok artesian water	ND	ND	ND	488	5	13	14	0.27
Chachoengsao rain water	ND	ND	ND	366	ND	26	ND	0.11
Nakhon Nayok rain water	ND	ND	ND	ND	ND	25	ND	0.48
Chachoengsao tap water	ND	ND	ND	ND	ND	26	ND	0.14
Nakhon Nayok tap water	ND	ND	ND	ND	ND	12	6	0.03
Bangkok tap water #1	ND	ND	ND	ND	3	36	ND	0.35
Bangkok tap water #2	ND	ND	ND	ND	1	29	ND	ND
Bottled purified water #1	ND	ND	ND	488	ND	ND	8	0.17
Bottled purified water #2	ND	ND	ND	366	5	39	8	0.16
Bottled purified water #3	ND	ND	ND	ND	ND	ND	7	ND
Local bottled mineral water #1	ND	ND	ND	488	ND	ND	8	0.20
Local bottled mineral water #2	ND	ND	ND	427	5	76	15	ND
Local bottled mineral water #3	ND	ND	ND	366	6	39	8	0.28
Imported bottled mineral water #1	ND	ND	ND	427	14	117	ND	0.54
Imported mineral water #2	ND	ND	ND	427	17	73	6	0.11
Sport drink #1	943	149	1205	ND	ND	ND	ND	0.23
Sport drink #2	851	172	1347	ND	ND	ND	ND	0.18
Thailand Tap Water Standard[†]			250			100–300		0.3

ND = non-detectable.
[†] in agreement with WHO 2011 [15,16].

cides widely used in the agricultural fields and from washing powders in the wastewater runoff. The artesian water is a ground water. It was partly protected from surrounding environment by the pipe wall, and thus it was clearer than the surface water. The artesian water was fairly yellow and had substantial iron contents. Their TDS, hardness, and mineral components were similar to that of surface water from the same province, which, according to a previous report [21], should have derived not only from lithogenic origin but also from pollutants closely related to adjacent polluted surface water. The water from Nakhon Nayok had a high amount of phosphate, which might be a result of chemical fertilizers and pesticides used in the farm lands. Rain water samples were slightly acidic feasibly because they reacted with gaseous acidic pollutants [22]. Their calcium contents ought to have arrived from contamination of calcium dust pollutants in the atmosphere [23]. Nakhon Nayok rain water was stored in a metal tank covered by a metal lid, thus its high iron concentration should have come from the corroded metal tank or lid as reported [19,24].

Tap water is the treated surface water and, in Thailand, its quality must be compliant with the WHO water quality standard guideline [15]. From Table 1, the tap water samples were slightly acid which might be a result of ion removal in the treatment process [25,26]. The tap water from Nakhon Nayok had a negligible amount of iron because it was collected from a newly constructed building with a new plumbing system. Likewise, tap water from one building in Bangkok had no iron detected because at the time when water was collected, the pipeline in that building was wholly changed from metal to polyvinyl chloride. Two other samples were yellowish relating with their iron contents. The results advocate that the amounts of iron in tap water should mainly come from corroded aged metal pipe in the houses or the status of residential plumbing system [11]. Phosphate in the Nakhon Nayok tap water was detected which might relate to widely chemical fertilizers and pesticide used in the farms. Some people mistrust the purity of tap water and prefer to spend money on bottled purified water which is believed to be safer, cleaner, and of

better taste than tap water[1]. Regarding the mineral contents, the bottled purified water sample #2 had nothing different from tap water. Moreover, phosphate, which was mostly undetected in tap water, was detected in all bottled waters which should be added from bottle cleansing agents and if they were improperly stored; phosphate might have come from dissolved bottle plastic. Iron was detected in samples #1 and #2 which might have derived from the corroded metal pipe or container used in the water treatment or packaging. Ion removal can cause water to be more aggressive in seeking for ion replacement including iron from the aged cast iron pipes[25,26], thus filtration or reverse osmosis may enhance iron dissolution from a corroded metal pipe. Bottled mineral water is the ground water expected to contain high amounts of natural minerals[27,28] especially calcium and magnesium. Inasmuch as there is a negative association between incidence of cardiovascular disease and the amounts of calcium and magnesium intake, the bottled mineral water has been promoted as a supplementary contribution to calcium and magnesium intake[29]. From Table 2, the domestic bottled mineral water #1 had no detectable calcium or magnesium. The results from imported bottled mineral water support previous reports[30,31] that the amount of minerals in some European bottled mineral water was lower than indicated on the labels. Sport drink is also promoted as a mineral supplement. Unlike the bottled mineral water, chemical substances can be added to the sport drink. They were amber yellow but did not correlate with their small iron amounts, therefore, their colour might come from an additive substance. Both had pleasant odour and salty sweet taste due to addition an aromatic compound, sugar, and salt to serve the consumers' favour. Because they had high amounts of NaCl, drinking them may unnecessarily increase sodium intake to a level that may be detrimental to health, especially for individuals on a sodium restricted diet[31]. Bottled water, particularly mineral water, and sport drinks are costly, however, their quality and health benefit may not justify their price. In fact, some are identical to the tap water. Normally, individuals receive nutrient minerals mainly from dietary foods. Drinking water containing high levels of calcium, magnesium, and potassium can be crucial in the prevention of magnesium deficiency[5,32] as well as contribute significantly to the daily calcium and potassium intake for persons with calcium or potassium-deficient diets[10,33–35].

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