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Drinking Water Engineering and Science Discussions

Interactive comment on "Evaluation of Changes in Some Physico-Chemical Properties of Bottled Water Exposed to Sunlight in Bauchi, Nigeria" *by* Rose E. Daffi and Fwangmun B. Wamyil

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Dear Referee, our appreciation for your meticulous observations which are duly noted and will be included in the revised version of the paper. Kindly find our responses to your comments:

[a.] General comments: - Not much emphasis is given to the compliance with EPA and WHO regulations. More important is the effect of PET bottles and sunlight on the quality.

Response: comments are kindly noted.

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[b.] The abstract is too long with too specific details on compliance with regulations

Response: Abstract has been updated as suggested in addition to RC1 comments.

[c.] Introduction has too many generalities, be more specific.

Response: Introduction has been updated in addition to RC1 comments.

[d.] Not clear why pH and nitrate are chosen as indicators for PET leaching. Consider at least removing nitrate as indicator.

Response: Though pH and Nitrate are not direct indicators for PET leaching, we decided to include them as they are parameters that were indicated on the products and we wanted to study/ensure that they were within acceptable range when exposed to sunlight. We have updated the sentences line in the paper (lines 92-95):

“This study seeks to investigate the changes in levels of specific parameters (Antimony, Bisphenol A, Nitrates, pH) in five (5) commercially available market brands of bottled water continually exposed to sunlight for 0 – 28days in Bauchi, Bauchi State and the effects on the quality of the water.”

[e.] Results frequently lacks critical discussion on mechanisms supported by literature.

Response: Comments are kindly noted.

[f.] Avoid recommendations in the paper.

Response: Recommendations have been removed/reviewed

[g.] Specific comments - Line 12-15: delete sentence

Response: Sentence has been deleted.

[h.] Line 22-24: delete sentence

Response: The recommendation in this section has been deleted and the first sentence edited in compliance with RC1 comments.

[i.] Line 28-33: delete sentence

Response: We saw a need to give an introduction that will enable the reader have a background information about the significance of water to the human body. Sentences have been deleted.

[j.] Line 35: delete sentence Response: This section is already deleted as per RC1 comments.

[k.] Line 58-69: delete sentences

Response: We feel there is a need to state the physical, chemical and biological properties of water. We have summarised the sentences as follows:

"The physical properties of water are colour, turbidity, temperature, taste and odour. The chemical properties of water are pH or the presence of chemicals like arsenic, Iron, Lead, Sodium, Zinc or other toxic organic or inorganic substances. Some chemicals are essential to human and animals in trace amounts, but prolonged exposure in higher amounts can be dangerous to human health. Chemicals can occur naturally from water source; whereas others are as a result of human activities (industrial-mining and human dwellings); agricultural activities (fertilizer and pesticide application); water treatment (supply lines, coagulants); pesticides (public health use); or containing vessels where water is stored (plastic bottles) (WHO, 2017)."

[l.] Line 70-72: delete sentences

Response: Section has been reviewed in accordance with RC1 comments as follows:

"Regulations specifically aim at ensuring the deleterious effects of the chemicals are avoided."

[m.] Line 76-86: delete sentences

Response: Section has been summarised in response to RC1 comments as follows:

"Radiological standards deal with water in contact with radioactivity. Parameters like alpha, beta particles, Radium-226, 228 and Uranium have standards set for drinking water to ensure no untoward health effects to human wellbeing when consumed (Davis, 2010). Radiation occurs naturally (accounting for almost 80% of dose from all radiation sources), from medical diagnosis (accounts for 19.6%) and from man-made sources (accounts for 0.4%) (WHO, 2017)."

[n.] Line 88: Table 1 is not a representative summary of drinking water standards

Response: Comment is kindly noted. Table 1 (see attached Fig. 1) has been updated and where we were able to the bottled water quality has been indicated in parenthesis. In addition, a number of regions adopt drinking water quality standards as bottled water quality standards unless localities institute different regulations.

[o.] Line 101: The = the

Response: correction has been made.

[p.] Line 105: after wards = afterwards

Response: correction has been made.

[q.] Line 121-139: this lacks a critical discussion. Why pH changes over time and why is it of importance? Drinking water standards are not relevant in bottled water:

Response: We had redone this section based on RC1 comments. In addition, we found the analysis applicable since no specific bottled water quality is adopted in the study area/study country. We have further edited it to include comments you have raised:

"The pH values obtained from the tests carried out for the five brands of bottled water are as given in Fig 1. The baseline (day zero) pH values for all brands ranged between 5.25 and 7.4. For the control sample at 14 day and 28 day, there was a general decrease of pH implying increase in acidity in the 5 brands. Brand A showed approximately 3.8% and 5.8% reduction in pH in day 14 and 28; Brand B-3.6% and 7.3%;

Brand C-5.4% and 9.2%; Brand D-13% and 20% (highest reduction); and Brand E-2.8% and 7% respectively. The final pH values at the 28 day for Brands A, B, C, D and E were 6.97, 5.93, 6.45, 4.17 and 6.07 respectively (Fig. 1). Samples exposed to direct sunlight had temperatures of 47°C and 56°C on day 14 and day 28 respectively with Brand A showing 15% and 20% reduction in pH at day 14 and day 28; Brand B-23.4% and 46.7%; Brand C-16% and 39%; Brand D-19.8% and 49%; and Brand E- 27% and 54.8% respectively. The final pH values at the 28 day for Brands A, B, C, D and E were 5.92, 3.41, 4.32, 2.67 and 2.95 respectively. The baseline pH values all fall within range of standard (NSDWQ and US-EPA: 6.5-8.5) except for Brands B and D. For the control samples at the 28 day only Brand A had pH at regulatory level (pH of 6.97). The sources of water may be one of the reasons for the pH values obtained for the control samples. Sample A is sourced directly from a spring aquifer which may explain why it has the lowest pH (Fisher et al., 2017), while samples B-E source water are from deep boreholes which might account for the changes in the values of pH noticed (Wright, 2015). The geology of the locations of water source may also have influence on the pH values. The sample exposed to sunlight had a lower pH (higher acidity) for each Brand and also as the days of exposure to sunlight increased. This is similar to research by (Muhamad et al., 2011), where samples were exposed to sunlight for 5 days (there was a decrease in pH with mean max temperature between 41oC to 47oC). However, the result from this study varies from investigation by (Akharame et al., 2018), where the pH values after the 28 day were all within the WHO and NSDWQ regulation levels. WHO has highlighted health effects of pH<4 to include eye redness and irritation and for pH<2.5 damage to epithelium (WHO, 2003b). The result suggests that sunlight exposure (temperature) affects pH of bottled water."

[r.] Line 148: is = was

Response: correction has been made.

[s.] Line 149: by (Bach et al., 2014) = by Bach et al. (2014)

Response: correction has been made.

[t.] Line 149: not clear. Increase in study of Bach was lower but 140% (which is higher)

Response: That section has been updated to provide a better clarity of expression as follows:

"In that research, water samples had increase in Antimony levels from 0.7μg/L to 0.8μg/L (about 27% or 1.4times the initial value) and 0μg/L to 0.5μg/L after the 10th day of exposing mineral (non-carbonated) and ultrapure water samples to sunlight respectively."

[u.] Line 168-171: delete sentences

Response: sentences have been deleted.

[v.] Line 176: is = was

Response: correction has been made.

[w.] Line 186-201: this lacks a critical discussion. Why nitrate changes over time? Consider deleting

Response: We have kindly retained and updated this section as per response stated in 'item d.'

[x.] Line 205-207: adjust depending on changes in the document

Response: We have kindly retained this section as per responses stated in 'items d. and w.'

[y.] Line 211: adjust depending on changes in the document

Response: We have redone this sentence as thus:

"The level of Nitrate leached as a result of sunlight exposure is within the limit set by NSDWQ and WHO."

[z.] Line 212-218: delete sentences.

Response: Sentences have been deleted.

Thank you.

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Table 1: Regulated Standards of Selected Physical, Chemical, Biological and Radiological Parameters

Parameter	NSDWO[a]	WHO[b]	US EPA[c] [FDA]	EU-DWD[d]	Government of Canada[e]	Suspected Health Effects[a,b,c,d,e]
Turbidity	5NTU		NA [5NTU]	4NTU	0.3-1NTU	Indicates inefficient water treatment process/distribution system.
Temperature	Ambient	-	-		<15°C	High temperature enhances microbial growth and problems associated with taste, odor, color and corrosion[a,e]
Color	15TCU	-	[15 color units]	20mg/L Pt/Co	<15TCU	Indicates unsafe water/presence of chemical or biological impurities.
pH	6.5 – 8.5	-	6-8.5		7-10.5	Acidic pH corrodes conduits & leach chemicals into water, irritate eyes.
Antimony (Sb)	-	20µg/L	6µg/L [6µg/L]	5.0µg/L	6µg/L	Affects blood (increase in cholesterol, decrease in sugar)
Arsenic (As)	0.2mg/L	10µg/L	[10µg/L]	10µg/L	10µg/L [10µg/L]	Affects Skin & nervous system, increases cancer risk
Lead (Pb)	0.01mg/L	10µg/L	15µg/L [5µg/L]	25µg/L	5µg/L [10µg/L]	Affects central and peripheral nervous system, cancer & kidney damage
E.coli	0cfu/100mL		0/100mL [0/100mL]	0/100mL	0/100mL [0/100mL]	Gastroenteric disease
Total coliforms	10cfu/100mL		0/100mL [0/100mL or <5% incidence/month]	0/100mL	0/100mL [10/100mL]	Gastroenteric disease
Alpha particles (α)(activity)	0.1Bq/L	0.5Bq/L	15pCi/L [15pCi/L]			Increases Cancer risks
Beta particles (β) (activity)	0.1Bq/L	1Bq/L	4 millirems per year [4 millirems per year]			Increases Cancer risks
Radium (Ra)-226 + Radium (Ra)-228	-	1Bq/L	5pCi/L [5pCi/L]		0.5Bq/L	Increases Cancer risks
Uranium	-	30µg/L	30µg/L [30µg/L]			Increases Cancer risks

Fig. 1.

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