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ASSESSMENT OF SOME DOMESTIC WATER SOURCES IN IRAGBIJI, BORIPE LOCAL GOVERNMENT, NIGERIA FOR POTABILITY USING WATER QUALITY INDEX

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ABSTRACT

Good health status of any water system is pivotal to its usability. This work aimed at assessing four streams (Alagaso, Ayeriyi, Elere and Arapayagi) in Iragbiji, Boripe Local Government Area of Osun State for portability using National Sanitation Foundation Water Quality Index (NSF-WQI). To achieve this, water samples were collected from the streams during wet and dry seasons and analysed for eight (8) physicochemical and biological parameters (pH, NO_3, Turbidity, PO_4, DO, E. Coli, DO and BOD) using America Public Health Association method of analysis. WQI was then computed using the mean values of the results of the concentrations of the parameters. The results of the analysis showed that while pH, PO_4, and NO_3 were within the established limits others were above. There was no seasonal variation in water quality of the four streams as indicated by WQI as they are rated as bad in the two seasons except for Alagaso stream which was rated as "bad" in the wet season and as "medium" in dry season. It was thus concluded the streams are not suitable sources of water for human consumption

Keywords: NSF-WQI, Drinking Water Quality Index, Seasonal Variation.

1. INTRODUCTION

Fresh surface water plays a major role in domestic water supply in most nations of the world. It usage varies with regions and parts of many country. While it is considered raw water by water cooperation in urban cities; it serves as the main water for consumption in many rural areas. Assessment of the state of this water system has become a topical issue because of the drastic reduction in the available water per person per year due to rapid growth in population (Shiklomanov, 2000).

Aside the issue of quantity, the quality of the available ones is often compromised either by nature or anthropogenic activities which deteriorate its quality through the entry of non point source and point source pollution (Ogedengbe and Akinbile, 2004). Hence, monitoring the

state of surface water of every community is paramount as water remains a vital environmental component for determining potential danger on the overall health status of the aquatic ecosystem as well as that of individuals in any community (Chang et al., 1999).

Personnel in the field of water resources often used the established limits by regulatory bodies of each country or by World Health Organisation (WHO) in assessing the change in the state of water system until recent time when the use of Water Quality Index (WQI) is being preferred as a better alternative (Rosemond, 2009). WQI is a rating reflecting the composite influence of different water quality parameters. It is an effective mathematical tool for communicating information on the quality of water to both experts in water resources and general public (Ahaneku and Animashaun, 2013). The computation of WQI involves a normalization step where the considered parameters are transformed into a 0 – 100 scale (Simoes *et al.*, 2008). The obtained value along the scale allows for adequate classification of water quality. Depending on the adopted WQI, while 0 represents very bad quality and 100 represents excellent quality of the water in some, it is vice- versa in others (Sanchez a *et al.*, 2007).

Osun State is not only blessed with fairly large rivers and their tributaries, it is also blessed with a number of streams of high environmental significance and economic importance. Some of such streams exist in Boripe Local Government. The streams are perennial and are used in wet and dry seasons for domestic activities including drinking, particularly in dry season when they become major sources of water. The aim of this study was to assess the suitability of those streams for human consumption using Water Quality Index.

2. MATERIALS AND METHODS

2.1 Study Area

The study area is Iragbiji, a town in Boripe Local Government, Osun State, Nigeria. Iragbiji is situated on the latitude 7° 54' 0" N and longitude 4° 40' 60" E and has an elevation of 429 meters above sea level. It has a land area of 132 km^2 and a population of 164,172 (getamap, 2016). It is characterized with both dry and wet seasons.

2.2 Sampling Procedure and Analysis

The study was carried out on four streams in Iragbiji town. The streams are Alagaso, Ayeriyi, Elere and Arapayagi which are located at Oloti area, Morinfin village, Ekukoro village and Arapayagi town respectively (Figure 1). The streams are of economic and environmental significance as they are being used for drinking purpose and other domestic functions. The water samples were collected from the four streams at the peak of wet and dry seasons of the year 2015. The samples were collected in a clean sterilized plastic bottle and analysed for eight (8) physicochemical and bacteriological parameters using standard methods recommended by the American Public Health Association, APHA (2003). The parameters

assessed include Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), *E. Coli,* Nitrate, pH, Temperature, Total phosphate and Turbidity. The results were analysed statistically using SPSS 16.0 package.

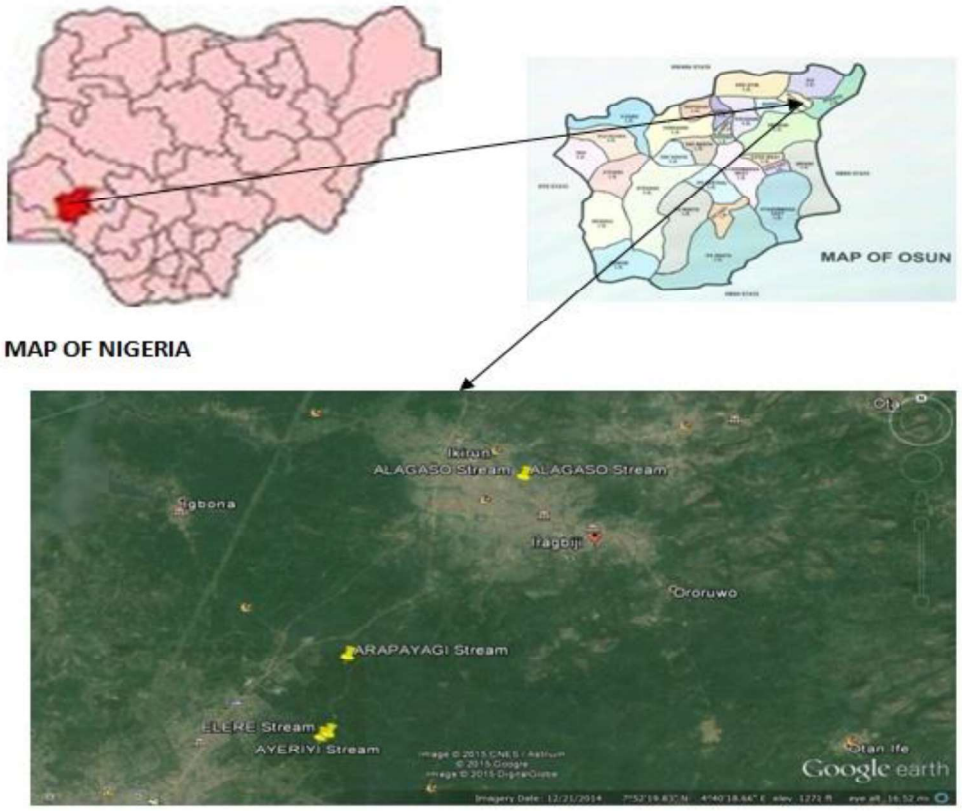

Figure 1: Map of the Study Area

2.3 Water Quality Index Computation

The index for each of the streams under consideration was established using National Sanitation Foundation Water Quality Index (NSF-WQI) calculator. NSF-WQI uses eight different water quality parameters (Table 1) in evaluating baseline water quality conditions and in identifying spatio-temporal trends in general water quality. Each of these parameters was assigned a weight on the calculator by NSF, based on their level of significance as identified by some expertise in water quality management (Basavarajappa *et al.*, 2013). The mean values from the statistical analysis were input into the calculator for the computation. The obtained results were used for the ranking of the streams based on the corresponding specific ranges each fell (Table 2).

Table 1: NSF-WQI Parameters and Weights

Water Parameter	Weighting Factor	WHO	NSDWQ
Dissolved Oxygen (% saturation)	0.18	-	-
E. Coli (CFU/100mL)	0.17	None	None
pH	0.12	6.7	6.5 – 8.5
BOD (mg/L)	0.12	30	-
Total Phosphates (mg/L)	0.11	5	-
Temperature (^{0}C)	0.11	25	Ambient
Nitrate Nitrogen (mg/L)	0.10	50	50
Turbidity (NTU)	0.09	5	

Source: Rosemond et al. (2009) and Animashaun and Ahaneku (2013)

Table 2: Water Quality Index Rating

Water Quality Index	Water Quality Ranking
0-25	Very Bad
26-50	Bad
51-70	Medium
71-90	Good
91-100	Excellent

Source: Rosemond *et al.* (2009) and WSDE (2002)

Description of the Rating

Excellent: Water quality meets all criteria for use as a source of drinking water.

Good: Water quality rarely or narrowly violates criteria for use as a source of drinking water.

Medium: Water quality sometimes violates criteria, possibly by a wide margin, for use as a source of drinking water.

Bad: Water quality often violates criteria for use as a source of drinking water by a considerable margin.

Very Bad: Water quality does not meet any criteria for use as a source of drinking water.

3. RESULTS AND DISCUSSION

3.1 Physicochemical and Bacteriological Indicators

The results of the water parameters showed that while some of the parameters assessed were within the established limits, others were above. The mean values for pH of the four streams assessed ranged from 6.3 to 6.9 (Table 3 and 4). pH level has significant effect on all body chemistry – river and man alike- (Avvannavar and Shrihari, 2007). During the wet season, the highest pH value was recorded at Ayeriyi Stream and the least at Arapayagi Stream, while the highest and least value during the dry season were obtained at Arapayagi and Elere respectively. Aside Elere which has a mean value of 6.3 during the dry season (Table 4), all

other streams have pH values that fell within the established limit (6.5 – 8.5) by Nigeria Standard for Drinking Water Quality (NSDWQ). However, the pH of Elere stream does not call for concern as water with pH value of 6.0 may not be harmful when consumed (Avvannavar and Shrihari, 2007).

Table 3: Descriptive statistics of the streams water quality parameters (Wet Season)

Stream	Statistics	pH	Temp (^{0}C)	DO (% sat.)	BOD (mg/L)	Turb. (NTU)	PO_4 (mg/L)	NO_3 (mg/L)	E.Coli (CF U/100mL)
Alagaso	Mean	6.80	26.40	31.73	36.00	2.00	0.21	8.60	0.00
	Maximum	7.00	27.70	45.30	37.80	3.00	0.23	8.80	0.00
	Minimum	6.60	25.40	5.30	34.20	1.00	0.19	8.40	0.00
	SD	0.20	1.20	22.90	1.80	1.00	0.02	0.20	0.00
Ayeriyi	Mean	6.90	26.60	29.20	84.00	90.00	0.04	24.70	9.00
	Maximum	7.00	28.20	30.00	96.80	94.00	0.50	25.70	11.00
	Minimum	6.80	25.00	28.40	71.20	86.00	0.30	23.70	7.00
	SD	0.10	1.60	0.80	12.80	4.00	0.01	1.00	2.00
Elere	Mean	6.70	26.80	34.20	68.00	62.80	0.05	16.20	3.00
	Maximum	6.90	28.00	36.60	82.00	64.20	0.06	16.40	4.00
	Minimum	6.50	25.10	31.80	54.00	61.40	0.04	16.00	2.00
	SD	0.20	1.80	2.40	14.00	1.40	0.01	0.20	1.00
Arapayagi	Mean	6.60	26.70	34.00	76.00	92.40	0.5	5.90	16.00
	Maximum	6.90	27.70	38.50	78.00	93.20	0.60	6.00	17.00
	Minimum	6.30	25.70	29.50	74.00	91.60	0.40	5.80	11.00
	SD	0.30	1.00	4.50	2.00	0.80	0.10	0.10	3.00

Table 4: Descriptive statistics of the streams water quality parameters (Dry)

Stream	Statistics	pH	Tempt (^{o}C)	DO (% sat.)	BOD (mg/L)	Turb. (NTU)	PO_4 (mg/L)	NO_3 (mg/L)	E.Coli (CF U/100mL)
Alagaso	Mean	6.50	26.80	92.80	18.40	2.00	0.24	0.44	0.00
	Maximum	8.00	27.00	93.70	18.60	3.00	0.28	0.46	0.00
	Minimum	6.00	26.60	91.90	18.20	1.00	0.22	0.42	0.00
	SD	1.00	0.20	0.90	0.20	1.00	0.03	0.02	0.00
Ayeriyi	Mean	6.50	26.90	55.50	37.80	82.30	0.22	0.09	5.00
	Maximum	6.70	28.80	57.00	38.40	88.70	0.24	0.11	6.00
	Minimum	6.30	25.00	52.30	37.20	75.90	0.20	0.07	4.00
	SD	0.20	1.90	2.40	0.60	6.40	0.02	0.02	1.00
Elere	Mean	6.30	27.00	75.20	31.20	65.70	4.00	0.1 0	11.00
	Maximum	6.50	28.80	76.60	33.70	67.50	5.00	0.11	12.00
	Minimum	6.10	26.40	73.80	28.70	63.90	3.00	0.09	10.00
	SD	0.20	1.30	1.40	2.50	1.80	1.00	0.00	1.00
Arapayagi	Mean	6.80	27.00	19.30	49.40	52.30	0.35	0.50	6.00
	Maximum	7.00	28.80	20.80	61.30	53.20	0.38	0.60	7.00
	Minimum	6.60	25.40	17.00	37.50	51.40	0.32	0.40	5.00
	SD	0.20	1.70	1.50	11.90	0.90	0.03	0.10	1.00

Temperature is considered an important parameter only when the integrity of the water system under consideration is assumed to have been compromised (Ahaneku and Animashaun, 2013). During the wet season, the temperature of the four assessed stream ranges between 26. 4 and 26.8 ^{o}C and during the dry season the observed temperature ranges between 26.8 and 27.0 ^{o}C. All the observed values were above the limit established by WHO. Dissolved oxygen measurement is very important for sustaining self-purification process of water systems. Unlike other parameters, the higher the amount of dissolved oxygen, the better the quality of the water. Depending on the water temperature, salinity and altitude, natural water in equilibrium with the atmosphere is expected to have dissolved oxygen concentrations ranging from about 5 to 14.5 mg/L (Avvannavar and Shrihari, 2007). During the wet season, the mean values for Stream Alagaso, Ayeriyi, Elere and Arapayagi were 45.3 % sat, 29.2 % sat, 34.2 % sat and 34.0 % sat respectively. During the dry season, their respective DO values were 92.8 % sat, 55.5 % sat, 75.2% sat and 19.3 % sat. Though, no limit is established by WHO and NSDWQ, the four Streams have above the minimum value of 5 mg/L by Canadian Council of Ministers of Environment (Ahaneku and Animashaun, 2013). DO is expressed in percentage saturation as recommended by NSF when using the Calculator.

The Biological Oxygen Demand (BOD) values for wet season ranges from 36 to 84 mg/L with Alagaso and Ayeriyi having the lowest and highest value respectively. During the dry season the maximum value for BOD (49.4 mg/L) was recorded at Arapayagi and the minimum (18.4 mg/L) at Alagaso. The results showed that only the Alagaso stream at dry season was found to be within permissible standard by WHO.

The turbidity of the streams ranged from 2.0 to 92.4 NTU over the two seasons. The results showed that only Alagaso Stream was less turbid, having 2.0 NTU at the two season, the remaining were found to be higher than the permissible limit of WHO (5 NTU). The low turbidity level of Alagaso stream could be because the stream is being assessed for drinking purpose at a point where it gushes out from the base of the rock. The stream has its source from *Okanyilule* hills and flows over a kilometer under the rock until it reaches point where it gushes out from the base of the rock. Consequently, there could be no room for intrusion of contaminants as the entry of suspended or colloidal organic and/or inorganic materials into the water is being prevented. Though, turbidity seems to be more concern with aesthetical state of water, it could give indication to the presence of pathogens as they are often encased in the particles.

The mean concentrations of phosphate recorded in wet season are 0.21, 0.04, 0.05 and 0.5 mg/L for Alagaso, Ayeriyi, Elere and Arapayagi respectively. During the dry season, the value ranged between 0.22 mg/L to 3.0 mg/L. The higher values recorded during the dry season could be as a result of reduction in water level leading to high concentration.

Nevertheless, the observed values are all below WHO threshold value of 5 mg/L for drinking water.

Nitrate is another important parameter that can be used to determine the health status of any water system. In this study, the values recorded for nitrate during the wet season ranged from 5.9 to 24.7 mg/L with maximum and minimum values in Arapayagi and Ayeriyi respectively. During the dry season lesser values (0.09 to 0.5 mg/L) were recorded across the streams. Higher values recorded during the wet season suggest runoff from agricultural or municipal waste (Morrison *et al*., 2001). However, the nitrate concentrations of the four rivers fell below the established limit by WHO (50 mg/L).

The amount of *E-coli* organism found in water sample of the four river ranges between 0 and 16 CFU/100ml. While Alagaso Stream was found to be free of the organism in dry and wet season, others were found to contain some amount of the organism. The *E. coli* content of the streams were reflected in the turbidity results as the least turbid river (Alagaso stream) contain no E. *Coli*. Microorganisms can attach to particulates; hence, turbidity can be a sign of possible microbial contamination (Akkoyunlu, 2012). The presence of *E.Coli* indicated high risk of health related problem on the users of the streams as a number of diseases are attributed to that (Avvannavar and Shrihari, 2007)

3.2 The streams Classification with NSF-WQI

Eight parameters were employed to establish an index for each of the stream in order to give an indication of the health status of the streams in wet and dry seasons. The mean values of the results (Test results) obtained were input and the other variables were generated by the NSF-WQI calculator. The values of the Weighting Factors (WF), Q - Values, subtotal and total for the observed values of each of the parameters examined in wet and dry seasons are presented in Table 5 and 6 respectively. The obtained values for total in Table 5 and Table 6 are the same as the index for each stream. Alagaso Stream has WQI of 50.43 and 68.40 in wet and dry seasons respectively. Thus, the stream can be rated as “medium” in both the wet and dry seasons (Figure 2). Ayeriyi stream has WQI of 39.15 in wet season and an index of 49.51 in dry season. Though, the values for the indices differ, they can both be rated as” bad”. Elere stream with respective WQI of 42.2 and 48.71 in wet and dry season can be rated as bad in the two seasons. Arapaya stream has WQI of 42.57 and 34.34 in wet and dry season respectively. The water quality rating for the stream in the two seasons is “bad”. The water quality index and rating for all the assessed streams showed that the streams water qualities have been compromised and thus not fit as a source of drinking water.

Table 5: Descriptive Statistics and Index Computation for the Streams (Wet Season)

Stream	Variables	pH	Tempt (0C)	DO (% sat.)	BOD (mg/L)	Turb (NTU)	PO_4 (mg/L)	NO_3 (mg/L)	E.Coli (CF U/100mL)	Total
	WF	0.12	0.11	0.18	0.12	0.09	0.11	0.1	0.17	
Alagaso	Test Result	6.80	26.40	45.30	36.00	2.00	0.21	8.6	0.0	
	Q – Value	84.87	12.3	36.24	2	92.12	48.88	19.7	97	
	Subtotal	10.18	1.35	6.52	0.24	8.29	5.38	1.97	16.49	50.43
Ayeriyi	Test Result	6.90	26.60	29.20	84	90.00	0.04	24.70	9.00	
	Q – Value	87.02	12.16	19.39	2	21.98	93.49	1	66.36	
	Subtotal	10	1.34	3.49	0.24	1.98	10.28	0.1	11.28	39.15
Elere	Test Result	6.70	26.80	34.20	68.00	62.80	0.05	16.2	3.0	
	Q – Value	82	12.02	23.61	2	31.9	90.39	4.64	77.78	
	Subtotal	9.88	1.32	4.25	0.24	2.87	9.94	0.46	13.22	42.2
Arapayagi	Test Result	6.60	26.70	34.00	76.00	92.4	0.50	5.9	16.;	
	Q – Value	79.47	12.09	23.43	2	21.15	32.39	30.49	61.76	
	Subtotal	9.54	1.33	4.21	0.24	1.9	3.56	3.05	10.5	34.34

Table 6: Descriptive Statistics and Index Computation for the Streams (Dry Season)

Stream	Variables	pH	Tempt (0C)	DO (% sat.)	BOD (mg/L)	Turb (NTU)	PO_4 (mg/L)	NO_3 (mg/L)	E.Coli (CF U/100mL)	Total
	WF	0.12	0.11	0.18	0.12	0.09	0.11	0.1	0.17	
Alagaso	Test Result	6.50	26.80	92.80	18.40	2.00	0.24	0.44	0.00	
	Q – Value	76.0	12.03	95.93	15.5	92.12	44.88	90.78	97	
	Subtotal	9.15	17.127	1.86	8.29	4.94	9.08	16.49	0.17	68.40
Ayeriyi	Test Result	6.50	26.90	55.50	37.80	82.30	0.22	0.09	5.00	
	Q – Value	76.26	11.96	51.43	2.00	24.19	47.80	97.88	72.47	
	Subtotal	9.15	1.32	9.26	0.24	2.18	5.26	9.79	12.32	49.51
Elere	Test Result	6.30	27	75.2	31.20	65.70	4.00	0.10	11.00	
	Q – Value	68.87	11.89	81.57	2.00	30.46	6.99	97.83	64.27	
	Subtotal	8.26	1.31	14.68	0.24	2.74	0.77	9.78	10.93	48.71
Arapayagi	Test Result	6.80	27.00	19.30	49.40	52.30	0.35	0.50	6.00	
	Q – Value	84.87	11.89	12.97	2.00	37.75	38.9	88.9	70.58	
	Subtotal	10.18	1.31	2.33	0.24	3.4	4.22	8.89	12	42.57

The result agrees with the findings of earlier researchers who upon the application of an index rated all fresh waterbodies assessed or the locations of a particular water system assessed as bad or unsuitable for drinking (Yogendra and Puttaiah, 2008; Sanchez, 2007; Thakor et al., 2011).

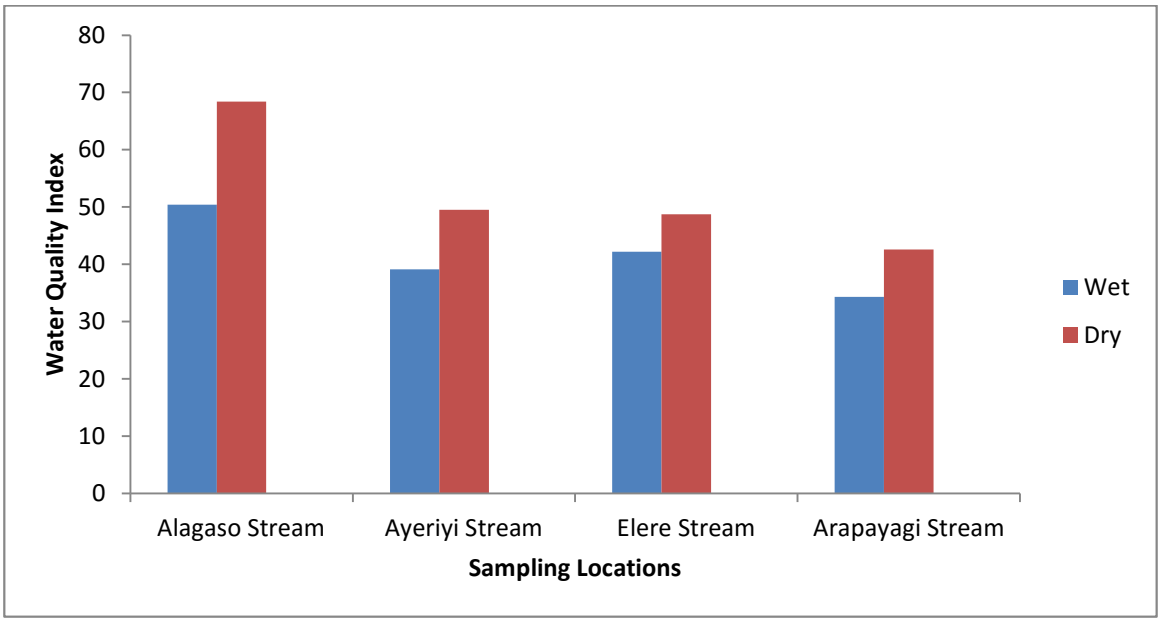

Figure 2: Seasonal Variation of WQI for the streams

4. CONCLUSION

The result of the study revealed that the streams Alagaso, Ayeriyi, Elere and Arapayagi failed water quality index assessment and thus not suitable as sources of drinking water. The rating of three of the streams as bad indicated that for them to be considered as suitable for public consumption, extensive treatment must be carried out. The study also showed that though a parameter may be within the established limit, yet the water will still not be suitable for drinking. Water Quality Index Calculator was a useful tool for its simplicity and time-saving attributes. The failure of Alagaso stream with little or no visible anthropogenic influence may suggest a base flow from polluted groundwater. Groundwater in the area therefore needs to be examined.

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