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THE EFFECTS OF WELL DEPTHS PROXIMITY ON WATER QUALITY IN VILLAGES NEAR BIU DAM, BIU LOCAL GOVERNMENT AREA, BORNO STATE

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ABSTRACT

The effect of well depth and proximity on water quality in villages near Biu dam in Borno state was carried out. The physicochemical parameters were carried out in two seasons: dry and wet season. Water in Wells of 2.7 to 9.3 m depth and proximity of 600 to 900 m from dam were investigated and compared with standard permissible limits for drinking water. A total of 150 samples were collected from 5 different Wells, inMaduksu, Mbirkim and Tsawuyamzimta villages of Biu. Results showed that the pH values fluctuated between 5.8 and 7.2; and increased from dry to wet seasons. The turbidity increased from 0.060 to 1.30 Nephelometric turbidity units (NTU) in the dry season to wet season. It was also observed that the biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids with the exception of total hardness increased from dry to the wet seasons. Nitrate and phosphate also fall within the permissible limits. It was observed that there is strong relationship between the parameters of dry and wet seasons. There was also a strong relationship between the physicochemical parameters of the well water in the villages and their proximity to the dam. MS-Excel and SPSS revealed that there is a significant relationship between the depth of the well and its' proximity to the Dam

INTRODUCTION

Water is essential for the survival of every form of life and the need for water is constantly increasing due to high rates of population growth and urbanization. However, the increased demands on water for drinking, domestic agricultural and industrial purposes are not commensurate with water availability [1, 2]. Groundwater represents an important source of drinking water and constitutes the largest source of dug well water [3]. Water from these shallow and deep wells is often of better quality than surface open water sources, if the soil is fine-grained and its bedrocks do not have cracks, crevices, and bedding plants, which permit the free passage of polluted water [4,5]. The availability and purity of groundwater are affected by location, construction, and operation of the wells [6]. It is often assumed that natural, uncontaminated water from deep wells is clean and healthy, and this is usually true with regards to bacteriological composition [7].

In many developing countries and including Nigeria, treated pipe borne water availability is limited and inadequate for the teeming population, thus, an increasing number of people in semi-urban and urban areas in Nigeria depend on dug wells and water vendors for water supply [8].

Hand dug wells have been the sources of water for people in Nigeria for ages [9]. A record indicates that some of these wells are dug within close proximity to rivers and these rivers are the main different contamination of ground water and lake [10]. Although, shallow ground water is affected more by contamination compared with deep groundwater [11]. In cases where agricultural land is located near a well, pesticides and nutrients (such as nitrate) are contaminants potentially found at the subsurface along a deficient well [11].

The main aim of this study was to ascertain the quality of the well water from the sources and find out the degree to which it meets the standards

MATERIAL AND METHODS

Study area

This study was carried out in three villages in Biu local Government namely: Tsawuyam Zimta, Mbirkim and Maduksu located near Biu Dam in Borno state. Biu is located on latitude 10°36'39.96"N and longitude 12°11'42.00”. The LGA is mostly located in the northern Guinea savannah (NGA) agroecological zone [12], with a small portion in the northeast, the Kimba area, lying in the dryer Sudan savannah zone [12]. These areas have two seasons, wet season (May – October, 2016) and dry season (November – April, 2016) [13].

Sample collection

The samples were collected in dry (November – April, 2016) and wet (May – October, 2016) season from the same source respectively. A total of 150 samples were collected and analyzed. The water samples were collected in sterile containers previously cleaned by washing using detergent, rinsed with tap water, later soaked in 10% HNO_3 acid for 24 h and finally rinsed with deionized water prior to usage [14].

The samples were labeled at the site of collection, stored in and transported immediately to the laboratory for further analysis [15].

Statistical Analysis

The relationship between heavy metal concentrations of dry and wet season were carried out using Microsoft Excel. Regression and Correlation were analyzed by using Statistical Package for Social Science (SPSS).

The relationship between the heavy metal concentrations, the proximity to the dam, and depth of the well were carried out by Pearson correlation tests. All analysis were determined at significant level of $P>0.05$.

Determination of physicochemical parameters

The temperature, pH and conductivity of the well water collected were determined in situ following the method of the Americal Public Health Association [16]. Determination of other parameters was measured in the laboratory. These include turbidity (using turbidity meter). Total Hardness using (Titrimetry, EBT/EDTA), dissolved oxygen (using Winklers Azide), biochemical oxygen demand (BOD) (using Winklers Azide), nitrate and phosphate (UV spectrophotometer) using standard method [17, 18]. Acid digestion of the water was carried out by using a 2:1 of concentrated HNO_3 and HCL [16]. Concentrations of the heavy metals (Cd, Ni, N, Cu, Mn, Pb, and Zn) in the water after digestion were analyzed using Atomic Absorption Spectrometer (Shimazu- AA- t300). The results from the AAS were expressed as µg/g which was converted to mg/kg in the results obtained. All reagents used were of analytical grade

The absorbance measurements of the standards and the sample solutions were read at appropriate wavelengths using a single element hallow cathode lamp on the spectrometer, equipped with automatic background correction [19]. Quality assurance for the analyses was conducted through spiking method, to evaluate the sample digestion process and effectiveness of the atomic absorbance spectrophotometer [20].

RESULTS AND DISCUSSION

Table 1: Sources, proximity of well to the dam and depth of the well

S/N	Sample ID	Sources	Proximity to the dam (m)	Depth of well (m)
1	M1	Maduksu	900	9.0
2	M2	Maduksu	900	8.7
3	M3	Maduksu	900	6.8
4	M4	Maduksu	900	9.3
5	M5	Maduksu	900	6.7
6	Mb1	Mbirkim	850	5.3
7	Mb2	Mbirkim	850	6.0
8	Mb3	Mbirkim	850	4.5
9	Mb4	Mbirkim	850	5.2
10	Mb5	Mbirkim	850	5.1
11	T1	TsawuyamZimta	600	3.6
12	T2	Tsawuyam Zimta	600	2.9
13	T3	TsawuyamZimta	600	4.2
14	T4	TsawuyamZimta	600	4.1
15	T5	TsawuyamZimta	600	2.7

The table above shows the source from which the well water samples werecollected, the depth of the well and its proximity to the Dam. The table revealed that the closer the proximity to the dam, the lower the depth of the well water in the surrounding. Better results were obtained in dry season.

		Parameter assessed	Dry season (mg/L)	Wet season (mg/L)	Proximity to the dam	Depth of the well
1	M1	PH	6.0	6.5	900	9.0
		Turbidity	0.51	0.96	900	9.0
		TH	515	150	950	9.0
		TDS	420	1000	900	9.0
		TSS	170	198	900	9.0

		TS	100	180	900	9.0
		BOD	0.19	0.20	900	9.0
		COD	210	177	900	9.0
		Nitrate	3.91	3.89	900	9.0
		Phosphate	1.46	3.7	900	9.0
2	M2	PH	5.8	6.1	900	8.7
		Turbidity	0.78	0.11	900	8.7
		TH	270	210	900	8.7
		TDS	255	1200	900	8.7
		TSS	287	388	900	8.7
		TS	125	170	900	8.7
		BOD	0.2	0.31	900	8.7
		COD	180	200	900	8.7
		Nitrate	4.0	7.0	900	8.7
		Phosphate	1.5	4.0	900	8.7
3	M3	PH	6.5	6.7	900	6.8
		Turbidity	0.84	1.37	900	6.8
		TH	310	310	900	6.8
		TDS	570	1400	900	6.8
		TSS	130	320	900	6.8
		TS	800	1000	900	6.8
		BOD	0.22	0.29	900	6.8
		COD	230	710	900	6.8
		Nitrate	4.1	6.3	900	6.8
		Phosphate	10.7	3.9	900	6.8
4	M4	PH	6.7	6.7	900	6.8
		Turbidity	0.06	0.70	900	9.3
		TH	420	420	900	9.3
		TDS	680	900	900	9.3
		TSS	143	150	900	9.3
		TS	105	1050	900	9.3

		BOD	0.17	0.59	900	9.3
		COD	105	726	900	9.3
		Nitrate	3.92	6.7	900	9.3
		Phosphate	11.8	8.2	900	9.3
5	M5	PH	6.2	6.5	900	6.7
		Turbidity	0.07	0.61	900	6.7
		TH	540	390	900	6.7
		TDS	905	920	900	6.7
		TSS	133	910	900	6.7
		TS	820	1820	900	6.7
		BOD	0.10	0.55	900	6.7
		COD	150	800	900	6.7
		Nitrate	3.98	7.3	900	6.7
		Phosphate	11.9	9.7	900	6.7
6	MB1	PH	7.0	7.0	850	5.3
		Turbidity	1.25	1.40	850	5.3
		TH	621	190	850	5.3
		TDS	800	1450	850	5.3
		TSS	250	1051	850	5.3
		TS	627	927	850	5.3
		BOD	0.35	0.60	850	5.3
		COD	120	590	850	5.3
		Nitrate	4.20	12.0	850	5.3
		Phosphate	1.22	10.1	850	5.3
7	MB2	PH	6.8	7.0	850	6.0
		Turbidity	1.30	1.24	850	6.0
		TH	700	404	850	6.0
		TDS	900	1010	850	6.0
		TSS	380	1090	850	6.0
		TS	540	841	850	6.0
		BOD	0.30	0.42	850	6.0

		COD	120	160	850	6.0
		Nitrate	4.32	7.2	850	6.0
		Phosphate	12.0	11.0	850	6.0
8	MB3	PH	6.6	7.1	850	4.5
		Turbidity	0.89	1.23	850	4.5
		TH	809	240	850	4.5
		TDS	750	980	850	4.5
		TSS	130	470	850	4.5
		TS	590	239	850	4.5
		BOD	0.25	0.42	850	4.5
		COD	140	289	850	4.5
		Nitrate	3.99	6.1	850	4.5
		Phosphate	7.2	13.5	850	4.5
9	MB4	PH	6.3	6.5	850	5.2
		Turbidity	1.10	1.27	850	5.2
		TH	590	308	850	5.2
		TDS	902	1330	850	5.2
		TSS	270	170	850	5.2
		TS	440	477	850	5.2
		BOD	0.27	0.38	850	5.2
		COD	200	300	850	5.2
		Nitrate	3.97	4.3	850	5.2
		Phosphate	6.1	8.2	850	5.2
10	MB5	PH	6.2	6.4	850	5.1
		Turbidity	1.09	1.28	850	5.1
		TH	670	170	850	5.1
		TDS	700	899	850	5.1
		TSS	400	827	850	5.1
		TS	320	199	850	5.1
		BOD	0.18	0.50	850	5.1
		COD	340	380	850	5.1

		Nitrate	4.22	2.8	850	5.1
		Phosphate	5.0	8.2	850	5.1
11	T1	PH	6.7	6.5	600	3.6
		Turbidity	0.61	0.71	600	3.6
		TH	815	245	600	3.6
		TDS	310	789	600	3.6
		TSS	440	981	600	3.6
		TS	105	280	600	3.6
		BOD	0.40	0.30	600	3.6
		COD	179	420	600	3.6
		Nitrate	4.27	3.9	600	3.6
		Phosphate	4.3	9.1	600	3.6
12	T2	PH	6.1	6.1	600	2.9
		Turbidity	0.54	0.89	600	2.9
		TH	250	130	600	2.9
		TDS	590	909	600	2.9
		TSS	425	700	600	2.9
		TS	259	170	600	2.9
		BOD	0.37	0.29	600	2.9
		COD	270	400	600	2.9
		Nitrate	3.91	3.8	600	2.9
		Phosphate	2.8	5.2	600	2.9
13	T3	PH	5.9	6.0	600	4.2
		Turbidity	0.72	1.17	600	4.2
		TH	530	135	600	4.2
		TDS	692	1050	600	4.2
		TSS	175	189	600	4.2
		TS	397	378	600	4.2
		BOD	0.37	0.35	600	4.2
		COD	290	529	600	4.2
		Nitrate	3.90	5.7	600	4.2

		Phosphate	3.90	5.9	600	4.2
14	T4	PH	7.0	7.0	600	4.1
		Turbidity	0.91	1.28	600	4.1
		TH	390	390	600	4.1
		TDS	823	1560	600	4.1
		TSS	189	1050	600	4.1
		TS	480	925	600	4.1
		BOD	0.39	0.40	600	4.1
		COD	180	590	600	4.1
		Nitrate	4.11	3.8	600	4.1
		Phosphate	3.8	1.7	600	4.1
15	T5	PH	6.5	6.6	600	2.7
		Turbidity	0.69	1.20	600	2.7
		TH	800	135	600	2.7
		TDS	749	1040	600	2.7
		TSS	455	1502	600	2.7
		TS	908	1820	600	2.7
		BOD	0.26	0.47	600	2.7
		COD	348	818	600	2.7
		Nitrate	4.01	5.6	600	2.7
		Phosphate	5.7	9.9	600	2.7

Note: M = Maduksu; MB = Mbirkim; TS = Tsawuyamzimta

Results in Table 2 showed that the PH values fluctuated between 5.8 and 7.2. The PH values increases from dry to wet season at M1, M2, M3, M5 Mb2, Mb3, Mb4, Mb5, T3 and T5 both same values were recorded at M4, Mb1, T1, and T3. The permissible limits for drinking water are 6.0 – 9.0 specified by World Health Organization [21]. The pH values in the table shows slightly neutral trend. Generally, pH affects the dissolved oxygen level in the water, photosynthesis of aquatic plants, metabolic rates of aquatic organisms and the sensitivity of these organisms to pollution, parasites and diseases [18].

Turbidity of the 15 different wells ranged from 0.060 to 1.30 NTU in the dry season and 0.611 to 1.37 NTU in the wet season. It showed that the turbidity increased from the dry to wet season with the exception of M2 and Mb2 with maximum value of 1.37 NTU and 1.30 NTU in the dry season. Governments have set standards on the allowable turbidity in drinking water. In the United States, systems that use conventional or direct filtration methods, turbidity cannot be higher than 1.0 NTU at the plant outlet and all samples for turbidity must be less than or equal to 0.3 NTU for at least 95 percent of samples in any month. Systems that use filtration other than the conventional or direct filtration must follow State limits, which must include turbidity at no time exceeding 5 NTU. Many drinking water providers strive to achieve levels as low as 0.1 NTU [22]. The European standards for turbidity state that it must be no more than 4 NTU (Consumers Advice Standards). The World Health Organization establishes that the turbidity of drinking water should not be more than 5 NTU, and should be ideally below 1 NTU [23]. Turbidity in open water may be caused by growth of phytoplankton, human activities that disturb land, such as construction, mining and agriculture, can lead to high sediment levels entering water bodies during rain storms due to storm water runoff. Areas prone to high bank erosion rates as well as urbanized areas also contribute large amounts of turbidity to nearby waters, through storm water pollution from paved surface such as road, bridges and parking lots [22]. Some industries such as quarrying, mining and coal recovery can generate very high levels of turbidity from colloidal rock particles. In drinking water,, the higher the turbidity level, the higher the risk that people may develop gastrointestinal diseases [24]. This is especially problematic for immune-compromised people, because contaminants like viruses or bacteria can become attached to the suspended solids. The suspended solids interfere with water disinfection with chlorine because the particles act as shields for the virus and bacteria. Similarly, suspended solids can protect bacteria from ultraviolet (UV) sterilization of water (Turbidity of water and its measurement)

The Total Hardness (HT) of water sample from different locations were observed in the ranges of 250 to 845 mg/L of $CaCO_3$ in the dry season and 130 to 420 mg/L $CaCO_3$ in the wet season. The same values were recorded at M3, M4 and T2. The values decreased directly from dry to wet season. T1 has the highest value at 845 mg/L in the dry season while 420 mg/L was recorded as the highest value at M4 in the wet season.

In domestic settings, hard water is often indicated by a lack of foam formation when soap is agitated in water, and by the formation of lime scale in kettle and water heaters [25]. The World Health Organization says "there does not appear to be any convincing evidence that water hardness cause adverse health effect in humans" [21]. In fact, the United States National Research Council has found that hard water actually serves as a dietary supplement for calcium and magnesium [26]. Some studies have shown a weak inverse relationship between water hardness and cardiovascular disease in men up to a level of 170 mg calcium carbonate per liter of water [21]. Recommendation have been made for the maximum and minimum levels of calcium (40 – 80 ppm) and magnesium (20 – 30 ppm) in drinking water, and a total hardness expressed as the sum of calcium and magnesium concentrations of 2 – 4 mmol/L [27].

Other studies have shown weak correlation between cardiovascular health and water hardness [26, 28].

Some studies correlate domestic hard water usage with increased eczema in children [29, 30].

NIS has specified the maximum permissible limits of TH to be within 150 mg/L of $CaCO_3$ while the USEPA guidelines are within 500 mg/L of $CaCO_3$ in the dry season. The values of the dry season have comparatively higher TH values than the wet season. Due the hardness of water is not a pollution parameter it has no adverse effect on human health, it indicates water quality and water with hardness above 200 mg/L may cause scale deposition in the water distribution system and more soap consumption [31, 32].

The TDS values in the well water samples were in the range of 255 to 902 mg/L in the dry season. All the TDS in the dry season were within the permissible limits with highest value at M4, while in the wet season were in the range of 789 mg/L to 1550 mg/L. The TDS increases drastically from the dry to wet season. Some TDS were below the permissible limits though some values were found to be above the permissible limit of 500 mg/L. TDS values at M1, T2 and T5 increased from the dry to wet season. The Total Dissolved Solid decreases the portability and may cause gastrointestinal irritation in human and may also have laxative effect particularly upon transits [25].

TSS value in the well water samples ranged from 287 mg/L to 455 mg/L in the dry season while at wet season ranges from 150 mg/L at M4 to 1506 at T5. It indicated that the total suspended solids increased from the wet to the dry season. High TSS can cause an increase in surface water temperature, because the suspended particles absorb heat from sunlight. This can cause dissolved oxygen level to fall even further (because warmer waters can hold less DO), and can harm aquatic life in many other ways [33]. The decrease in water clarity caused by TSS can affect the vision of fish in water. Suspended sediment can also clog fish gills, reduce growth rates, decrease resistance to disease, and prevent egg and larval development. When suspended solids settle to the bottom of a water body, they can smother the eggs of fish and aquatic insects, as well as suffocate newly hatched insect larvae. Settling sediments can fill in spaces between rocks which could have been used by aquatic organisms for homes [33].

High TSS in a water body can often mean higher concentration of bacteria, nutrients, pesticides and metal in the water. These pollutants may attach to sediment particles on land and be carried into water bodies with storm water. In the water, the pollutants may be released from the sediment or travel farther downstream [34].

TS value of the well samples ranged from 100 mg/L at M1 to 908 mg/L at T5 in the dry season and 922 mg/L at Mb4 to 1820 mg/L at M5 in the wet season. The samples values increased from the dry to wet season with the exception of sample at sites Mb2. The permissible limit of Total Solid is 200 mg/L. Most of the samples values were found to be above the permissible limits set by World Health Organization [21].

BODS were found in the range of 0.1 to 0.40 mg/L in the dry season and 0.2 mg/L to 0.6 mg/L in the wet season. The desirable limit for BOD is 4.0 mg/L and permissible limit is 6.0 mg/L. BOD demand below 3 mg/L or less is required for best use [31]. Biochemical Oxygen Demand is also known as Biological Oxygen Demand (BOD). It is the amount of dissolved oxygen needed (demanded) by aerobic biological organisms to break down organic materials present in a given water sample at certain temperature over a specific time period. The BOD value is most commonly expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20°C. It is often used as a surrogate of the degree of organic pollution of water [35].

It was observed that the COD values in all 15 wells in dry seasons varied from 105 mg/L at M4 to 349 mg/L at T5 in the dry season and 160 mg/L at Mb2 to 819 mg/L at T5 in the wet season. The permissible limits of COD for drinking water are 255 mg/L [36]. The high value of COD in the study areas are due to the high levels of pollutant present in water samples [32].

The nitrate contents of the well water sample were found in the range of 3.88 to 4.24 mg/L in dry season and 2.8 mg/L to 12.0 mg/L during the wet season. These show that the nitrate content of the well water sample increased in the dry season with the exception of M3, M4 and T1. The nitrate content values fell within the WHO and NIS accepted limits for drinking water standards, except for sample M2 in the wet season which exceeded the permissible limit

Nitrate poisoning can occur through enterohepatic metabolism of nitrate due to nitrite being an intermediate. Nitrites oxidize the iron atoms in hemoglobin from ferrousiron (II) to ferric iron (III), rendering it unable to carry oxygen [37]. This process can lead to generalized lack of oxygen in organ tissue and a dangerous condition called methemoglobinemia. Although nitrite converts to ammonia, if there is more nitrite than can be converted, the animal slowly suffers from a lack of oxygen [38].

Relationship between the physicochemical parameters of the dry and wet season

Humans are subject to nitrate toxicity, with infants being especially vulnerable to

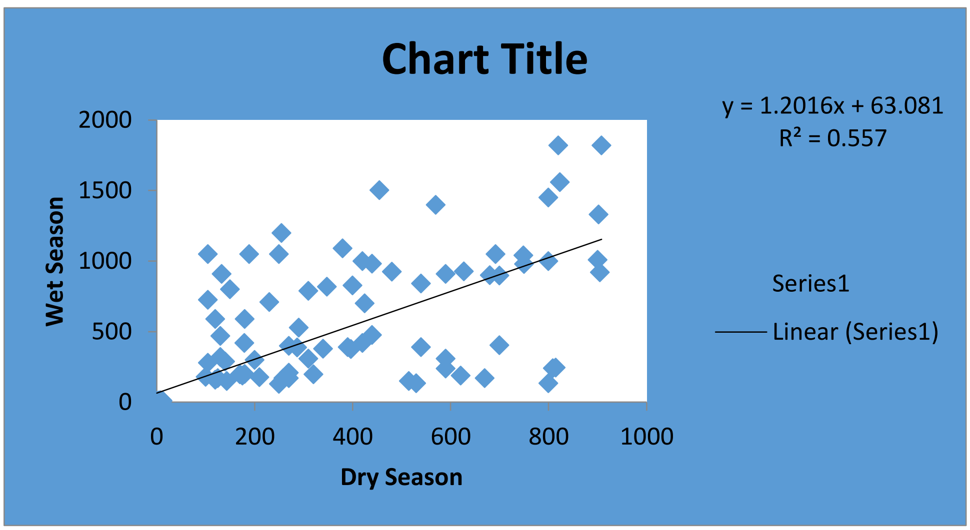

Fig 1: Relationship between physicochemical parameters of the dry and wet

methemoglobinemia due to nitrate metabolizing triglycerides present at higher concentrations than at other stages of development. Methemoglobinemia in infants is known as blue baby syndrome. Although nitrates in drinking water once were thought to be a contributing factor, there now are significant scientific doubts as to whether there is a causal link [39, 40].

The phosphate content of the well water samples were found in the range of 1.46 to 12.0 mg/L in the dry season and 1.71 to 13.5 mg/L was recorded at the wet season for all 15 samples. The recommended limit for phosphates in drinking water is 0.1 mg/L. Therefore none of the samples was within the acceptable limits

Fig 1 shows that the population is not normally distributed with R – Square, 0.557 which conformed to that of regression and correlation using Microsoft Excel

Regressions and correlations analysis using Microsoft excel and Statistical package for social science (SPSS) indicated that the R value was 0.746295in both Microsoft excel and SPSS. This implied that there is strong relationship between the physicochemical parameter of the dry and wet season. The p-value from the ANOVA using Microsoft Excel and Statistical Package for Social Science $5.997*10^{-28}$ and 0.00 respectively, implied that there is significant difference between the physicochemical parameters of the dry and wet season

The analysis showed that there is strong relationship between the physiochemical parameters of the well water in the villages and their proximity to the Dam. Also, the proximity of the well to Dam has a good relationship with the depth of the well because the closer the well to the dam the lower the depth of the well. There were high physicochemical properties than the villages at a far distance. For an instance, Tsawuyamzimta which is just 600 meters from the dam, the well depth fluctuates from 2.7 to 4.2 meters depth with high physicochemical properties during wet seasons than the other two villages (Mbirkim and Madusu) which were little bit far from the Dam

CONCLUSION

The effect of well depth on the physicochemical properties of well water of neighboring villages in close proximity to Biu dam were investigated and the results shows that there is strong relationship between the parameter of dry and wet season. It also revealed that there is strong relationship between the physiochemical parameters of the well water in the villages and their proximity to the dam, the proximity of the well to dam has a good relationship with the depth of the well.

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