Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol. 3, No.4, 2013

Determining Physico-Chemical and Bacteriological Parameters of Lipkova's River and Artificial Lake (System 1) In The Republic Of Macedonia

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Abstract

This paper presents the findings of a four-month study of samples of water taken from Lipkova River and artificial Lake (System 1) during 2012. The water samples, obtained from three different locations, underwent a study of their chemical, physical, and bacteriological parameters, which are good indicators of the quality of the water and aquatic ecosystems.

Many agents affect the quality of surface and groundwater, the most important of which are anthropogenic pollutants introduced through the drainage of sewage systems that contain organic matter, soluble compounds of phosphorus, nitrogen, substances that initiate the process of eutrophication, pathogenic bacteria and viruses, heavy metals as well as substances that disrupt the natural state of water giving it a foul odour. The physical, chemical and bacteriological parameters are good indicators of surface and groundwater quality and the state of aquatic ecosystems.

Keywords: surface water, groundwater, anthropogenic factors, drainage, sewage, physical and chemical parameters, bacteriological parameters, aquatic ecosystems, aquatic biota.

Introduction

The waters of the hydrosphere were "uncontaminated", or in their natural state until the beginning of the Industrial Revolution in Europe and North America. Now all the waters of the Earth, with the exception of those in the Poles, have been contaminated by anthropogenic activity [1] [2]. Pollution and the misuse of natural renewable water resources are considered a major problem of the global change syndrome. The rivers in developing countries especially suffer from greater deterioration of water quality [3].

Significant quantities of waste and untreated water are dumped into surface waters from residential areas, industrial activity, intensive livestock rearing, as well as agricultural production [4].

The failure to treat wastewater from residential areas, industrial emissions, the use of pesticides and insecticides in agriculture, seepage from animal dung and a lack of adequate treatment measures and reuse of waste, has led to a significant deterioration of the quality of surface water, but has also been damaging to the Earth's surface itself [5].

The main source of surface water pollution are emissions containing organic matter, soluble compounds of phosphorus and nitrogen, which intensify the process of eutrophication, pathogenic bacteria and viruses, heavy metals and substances that blemish the appearance of surface waters and give them a foul odour [6]. The dumping of urban, industrial and agricultural wastewater into surface waters is a phenomenon which has progressively impacted the deterioration of the water quality of rivers in particular and the environment in general [7]. The influence of anthropogenic factors on rivers is a process that leads to various negative consequences [8].

The physical, chemical and microbiological characteristics must be considered in order to determine water quality and its degree of pollution [9].

The physico-chemical and microbiological characteristics of water may undergo significant changes as a result of anthropogenic activities [10] [11].

Lipkova Region

The Lipkova region is situated in the northwestern part of the Republic of Macedonia, at N 42^0 09' and E 21^0 35' on the border with Kosova and Serbia (Fig. 1).

Fig. 1. Location of Lipkova region (source: www.d-maps.com)

Lipkova River

Lipkova River stretches for 17.5 km and is formed as a result of a confluence of the Goshinca, Brezë and Sllupçan rivers. As it flows eastward, it converges with the Tabanovc River, which then flows into the Kumanova River and finally pours into the Pçinja River (Fig. 2). Lipkova River feeds two artificial lakes - Lipkova (System 1) and Glazhnjë (System 2) [12].

Fig. 2. Lipkova Lake (source: http://commons.wikimedia.org/wiki/Category:Lipkovska_River)

Lipkova artificial lake (System 1)

The artificial lake of Lipkova (System 1) is situated 2 kilometers to the west of the village of Lipkova, at 524 meters above sea level. The lake is fed by the waters of Likpova River. The lake is 1480 meters in length, 120 meters in width and 37 meters in depth. It has a water volume of 1,500,000m^3 whereas 1,300,000m^3 is useable. A certain amount of the water is used by locals for irrigation during the summer, whereas the rest provides drinking water to the Kumanova's residents.

Objective of study

Lipkova River feeds two artificial lakes: Lipkova (System 1) and Glazhanjë (System 2). Local farmers use certain amounts of water from both lakes for irrigation during the summer, whereas the rest is used to provide Kumanova's resident with their drinking water.

The value of these two artificial lakes prompted a study of their water quality by monitoring the physical, chemical and bacteriological parameters, which are a good indicator of the quality of the water in the water ecosystems.

Materials dhe methods

Materials

The following materials were used in this study:

- Water samples;
- Peptone water;
- Lactose 1%;
- Andrade indicator;
- Membrane filters;
- Agar;
- Filters;
- Vacuum pump;
- Wulf's cup;
- Plastic tubes connecting filters;
- Laboratory dishes.

Water samples used to determine the physical, chemical and bacterilogical parametres were obtained from three locations: S1, S2 and S3 (Table 1).

Table 1. Table shows water sample sites, their coordinates and sea levlel.

Sample sites	Coordinates	Sea level
S1- Lipkova River near restaurant "Freskia"	42^0 10' 36.56" N; 21^0 33' 59.39" E	527 m
S2-Artificial Lipkova Lake (System 1) near restaurant "Panorama"	42^0 10' 0,6.17" N; 21^0 34' 13.20" E	524 m
S3- Lipkova River at entrance to village of Lipkova	42^0 09' 07.98" N; 21^0 35' 47.50" E	461 m

The three sample sites are located a certain distance from one another. Sample site S1 is 110 metres from S2, whereas S2 is 330 metres from S3. Sample sites S1 and S2 are presented in the satellite image below. (Fig. 3)

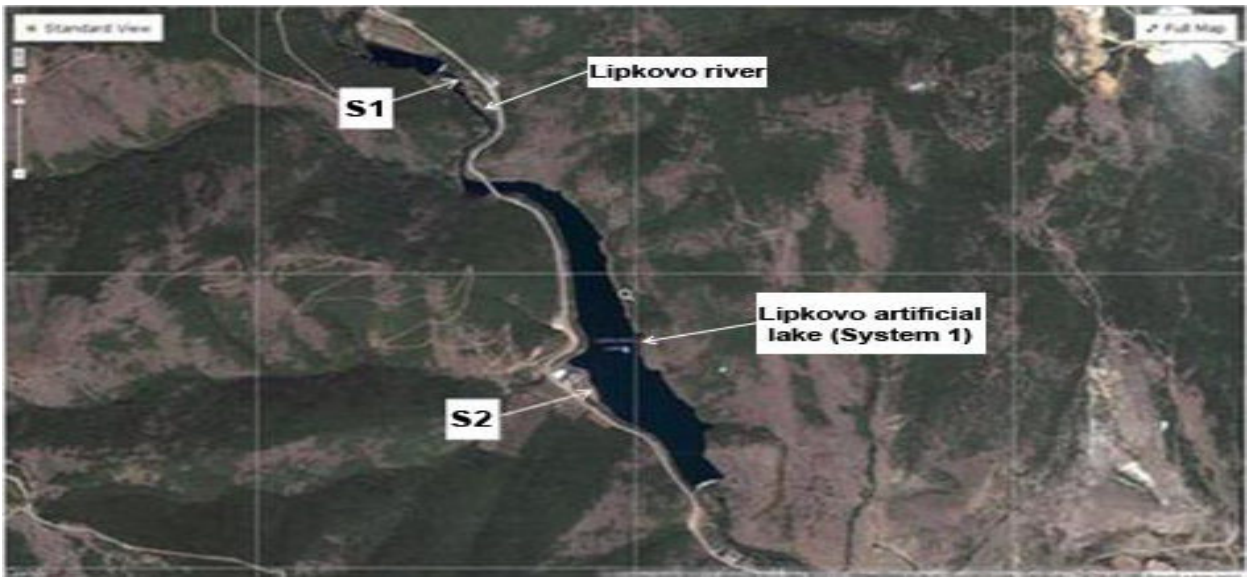

Fig. 3. Satellite image of Lipkova River and Lipkova artifical Lake (System 1) and locations from which water samples were obtained to determine the phycical, chemical and bacteriological parameteres (S1-Lipkova River near restaurant Freskia; S2-artifical Lake (System 1) near restaurant Panorama) (source:www.google.com/mapmarker).

The water samples from these three sites were taken to the Scientific Research Laboratary at the Faculty of Medicine, State University of Tetova, where the physical, chemical and bacteriological parametres were determined using a certain methodolgy and equipment (Table 2).

Methods

Table 2 shows the methods and instruments used to determine the physical, chemical and bacteriological parametres of the water in Lipkova River and artifical Lake (System 1).

Table 2. Methods and instruments used to determine the physical, chemical and baceteriological paramatres of the water samples obtained from three sites.

Parametres	
Physical parametres	**Methods, instrument**
Temperature	Thermistor
Aroma	Organoleptic method
Colour	Colorimetric method
Turbidity	Nephelometric method
Chemical parametres	
Dissolved oxygen	Oxygen sensor
Biochemical oxygen consumption	Iodometric method
Residue after evaporation	Gravimetric method
pH	pH meter
Consumption of $KmnO_4$	Huber and Tieman method
Nitrates	In acidic environment with 5% Burcin solution
Chloride	Titration method
Iron	Colorimetric method
Nitrites	Photometric method
Manganese	Photometric method
Magnesium	Photometric method
Copper	Photometric method
Lead	Photometric method
Zinc	Photometric method
Cadmium	Photometric method
Nickel	Photometric method
Chromium	Photometric method
Arsenic	Photometric method
Mercury	Photometric method
Sodium	Ionic chromatography
Potassium	Ionic chromatography
Bacteriological parametres	
Aerobic bacteria and facultative anaerobic heterotrophy	Number of saprophyte colonies at 22^0-26^0C, on thermostat
General coliform bacteria	Membrane filter method, in Difco-m Endo agar, at 37^0C, 24 h, on thermostat
Faecal coliform bacteria (thermotolerant)	Membrane filter method, in Difco-m FC agar, at 44^0C, 24 h, on thermostat
Escherichia coli bacteria	Membrane filter method, in Difco-m FC agar, at 44^0C, 24 h, on thermostat
Faecal streptococcus, i.e. enterococcus	Membrane filter method, in Difco-Enterococcus agar, at 44^0C, 24 h on thermostat
Coordinates and seal level	GPS

Results

Table 3 shows the results of the physico-chemical and bacteriological parametres from an analysis of water samples obtained from three sites during May, June, July and August 2012.

Table 3. Results of the physico-chemical and bacteriological parametres from an analysis of water samples obtained from S1 (Lipkova River near reastaurant "Freskia") during May, June, July and August 2012.

Physico-chemical parametres	Units of measurement	May	June	July	August	Maximum levels allowed
Temperature	^{0}C	13	7	9	9	25
Aroma	Points	None	None	None	None	None
Colour	Pt-Co	None	None	None	None	None
Turbidity	NTU	1.740	2.870	1.180	1000	1.000
Dissolved oxygen	mg/l	10.200	11.700	10.800	-	10.800
Biochemical oxygen consumption	mg/l	0.400	1.730	1.400	1.330	2.500
Residue after evaporation	mg/l	144.00	140.000	112.000	130.000	500.000
pH	-	7.78	8.15	7.4	7.26	8.5
Consumption of $KMnO_4$	mg/l	1.720	7.130	2.400	1.920	2.500
Suspended substances	mg/l	14.40	11.700	6.400	10.600	30.000
Amonia as nitrogen	mg/l	-	-	17.000	-	20.000
Nitrites as nitrogen	mg/l	4.860	2.000	3.300	2.430	10.000
Nitrates as nitrogen	mg/l	550.000	529.000	619.000	744.660	10.000
Chloride	mg/l	9.000	80.000	10.000	9.000	200.000
Iron	mg/l	60.000	58.000	60.000	None	300.000
Manganese	mg/l	None	None	None	60.000	50.000
Fluorides	mg/l	None	1.300	None	None	1.500
Calcium	mg/l	9.20	14.700	10.900	10.000	100.000
Magnesium	mg/l	4.300	11.100	2.400	3.100	50.000
Copper	mg/l	None	None	None	None	0.010
Zinc	mg/l	43.00	17.00	-	9.022	100.000
Lead	mg/l	None	None	None	17.222	10.000
Cadmium	mg/l	None	None	None	None	0.005
Nickel	mg/l	None	None	None	None	0.050
Chromium	mg/l	None	None	None	None	0.050
Arsenic	mg/l	0.050	None	None	None	0.050
Mercury	mg/l	None	None	None	None	0.001
Potassium	mg/l	None	None	None	None	12.000
Sodium	mg/l	None	None	None	None	150.000
Phenols	mg/l	None	None	None	None	0.001
Detergents	mg/l	None	None	None	None	0.200
Aluminium	mg/l	None	None	None	None	0.200
Cyanides	mg/l	None	None	None	None	0.050
Phosphates	mg/l	None	None	None	None	2.200
Sulphates	mg/l	23.700	26.000	14.700	13.500	200.000

The results of the physico-chemical parametres from an analysis of water samples obtained from S1 show an increased turpidity during May, June and July, the amount of dissolved oxygen in the water and the consumption of $KMnO_4$ were higher during June than other months and higher levels of manganese and lead were found in the water samples obtained from this location in August.

Table 4 shows the results of a bacteriological analysis of the water samples obtained from S1.

Table 4. Results of the a bacteriological analysis of the water samples obtained from S1 (Lipkova River near reastaurant "Freskia") during May, June, July and August 2012.

Bacteriological parametres	Units	May	June	July	August	Maximum levels allowed
Possible number of coliform bacteria	Nr. of bact./100ml	None	None	None	None	-
Fecal coliform bacteria	Nr. of bact./100ml	None	None	None	None	-
Aerobic mesophelic bacteria	Nr. of bact./100ml	1.000	0.800	0.500	0.800	-
Faecal streptococcus	Nr. of bact./100ml	None	None	None	None	-
Proteus species of bacteria	Nr. of bact./100ml	None	None	None	None	-
Sulphur-reducing bacteria	Nr. of bact./100ml	None	None	None	None	-
Pseudomonas aeruginosa	Nr. of bact./100ml	None	None	None	None	-
Escherichia coli	Nr. of bact./100ml	None	None	None	None	-

The results shown in table 4 indicate a presence of only aerobic mesophelic bacteria in the water sample obtained from this site.

Table 5 shows the results of the physico-chemical analysis of the water samples obtained from S2 during May, June, July and August 2012. The results clearly show above average levels of turbidity during all four months, a higher level of dissolved oxygen in the water only during May, higher levels of $KMnO_4$ in May and June, higher levels of suspended substances only in August, higher level of nitres during all four months and higher levels of lead only in August.

Table 5. Results of the physico-chemical parametres from an analysis of water samples obtained from S2 (Artificial Lipkova Lake **(**System 1) near restaurant "Panorama").

Physico-chemical parametres	Units of measurement	May	June	July	August	Maximum levels allowed
Temperature	^{0}C	13,7	19	20	17	25
Aroma	Points	None	None	None	None	-
Colour	Pt-Co	None	None	None	None	-
Turbidity	NTU	1.420	1.870	1.350	1.420	1.000
Dissolved oxygen	mg/l	11.000	9.790	-	-	10.800
Biochemical oxygen consumption	mg/l	1.200	2.100	1.270	1.830	2.500
Residue after evaporation	mg/l	155.000	124.000	133.000	144.000	500.000
pH	-	8.18	7.9	7.29	7.32	8.5
Consumption of $KMnO_4$	mg/l	7.130	5.800	-	-	2.500
Suspended substances	mg/l	10.900	2.000	15.700	40.800	30.000
Amonia as nitrogen	mg/l	None	10.000	17.000	000	20.000
Nitrites as nitrogen	mg/l	6.000	5.000	5.100	3.950	10.000
Nitrates as nitrogen	mg/l	703.000	500.000	528.000	423.000	10.000
Chloride	mg/l	9.000	8.000	9.000	13.000	200.000
Iron	mg/l	20.000	None	65.000	None	300.000
Manganese	mg/l	None	None	None	None	50.000
Fluorides	mg/l	0.030	None	None	None	1.500
Calcium	mg/l	8.30	9.50	12.200	9.900	100.000
Magnesium	mg/l	30.900	7.000	2.300	3.700	50.000
Copper	mg/l	None	None	None	None	0.010
Zinc	mg/l	50.000	None	None	18.229	100.000
Lead	mg/l	None	None	None	16.653	10.000
Cadmium	mg/l	None	None	None	None	0.005
Nickel	mg/l	None	None	None	None	0.050
Chromium	mg/l	None	None	None	None	0.050
Arsenic	mg/l	0.005	None	None	None	0.050
Mercury	mg/l	None	None	None	None	0.001
Potassium	mg/l	None	None	None	None	12.000
Sodium	mg/l	None	None	None	None	150.000
Phenols	mg/l	None	None	None	None	0.001
Detergents	mg/l	None	None	None	None	0.200
Aluminium	mg/l	None	None	None	None	0.200
Cyanides	mg/l	None	None	None	None	0.050
Phosphates	mg/l	None	None	None	None	2.200
Sulphates	mg/l	5.000	None	13.500	15.400	200.000

Table 6 shows the results of an analysis of the bacteriological parameteres of samples obtained from S2. The results indicate a presence of aerobic mesophelic bacteria durng June and July, whereas no other forms of bacteria were found in the water samples from this site.

Table 6. Results of the a bacteriological analysis of the water samples obtained from S2 (Lipkova Lake-System 1).

Bacteriological parametres	Units of measurement	May	June	July	August	Maximum levels allowed
Possible number of coliform bacteria	Nr. of bact./100ml	None	None	None	None	-
Fecal coliform bacteria	Nr. of bact./100ml	None	None	None	None	-
Aerobic mesophelic bacteria	Nr. of bact./100ml	None	1.000	1.000	None	-
Faecal streptococcus	Nr. of bact./100ml	None	None	None	None	-
Proteus species of bacteria	Nr. of bact./100ml	None	None	None	None	-
Sulphur-reducing bacteria	Nr. of bact./100ml	None	None	None	None	-
Pseudomonas aeruginosa	Nr. of bact./100ml	None	None	None	None	-
Escherichia coli	Nr. of bact./100ml	None	None	None	None	-

Table 7 shows the results of an analysis of the physico-chemical parameteres of samples obtained from S3. The results clearly show above average levels of turbidity during May, June and July, a higher level of dissolved oxygen in the water during June, higher levels of $KMnO_4$ consumption and suspended substances in May, higher level of ammonia and nitres in July, of nitrites, copper and lead during August, and higher levels of detergents during May and June.

Table 7. Results of the physico-chemical parametres from an analysis of water samples obtained from S3 (Lipkova River at the village's entrance).

Physico-chemical parametres	Units of measurement	May	June	July	August	Maximum levels allowed
Temperature	^{0}C	14	19	11,6	17	25
Aroma	Points	None	None	None	None	-
Color	Pt-Co	None	None	None	None	-
Turpidity	NTU	1.800	2.150	2.010	0.537	1.000
Dissolved oxygen	mg/l	9.100	12.300	10.800	-	10.800
Biochemical oxygen consumption	mg/l	2.100	1.400	1.350	1.830	2.500
Residue after evaporation	mg/l	131.000	208.000	130.000	285.000	500.000
pH	mg/l	6.5	7.5	6.72	7.58	8.5
Harxhimi i KMnO4	mg/l	9.730	2.000	-	-	2.500
Suspended substances	mg/l	39.500	20.000	5.300	9.800	30.000
Amonia as nitrogen	mg/l	16.000	15.000	26.000	000	20.000
Nitrites as nitrogen	mg/l	1.631	1.300	5.400	59.800	10.000
Nitrates as nitrogen	mg/l	0.025	0.080	688.000	4.028	10.000
Chloride	mg/l	7.000	18.000	7.000	14.000	200.000
Iron	mg/l	22.000	None	76.000	None	300.000
Manganese	mg/l	None	None	None	None	0.050
Fluorides	mg/l	None	None	None	None	1.500
Calcium	mg/l	9.600	36.000	12.200	21.100	100.000

Magnesium	mg/l	6.400	3.000	2.300	6.300	20.000
Copper	mg/l	None	None	None	139.950	10.000
Zinc	mg/l	None	None	None	None	0.100
Lead	mg/l	None	None	None	15.430	10.000
Cadmium	mg/l	None	None	None	None	0.005
Nickel	mg/l	None	None	None	None	0.050
Chromium	mg/l	None	None	None	None	0.050
Arsenic	mg/l	None	None	None	None	0.050
Mercury	mg/l	None	None	None	None	0.001
Potassium	mg/l	None	None	None	None	12.000
Sodium	mg/l	None	None	None	None	150.000
Phenols	mg/l	None	None	None	None	0.001
Detergents	mg/l	2.000	0.120	None	None	0.200
Aluminium	mg/l	None	None	None	None	0.200
Cyanides	mg/l	None	None	None	None	0.050
Phosphates	mg/l	None	None	None	None	2.200
Sulphates	mg/l	21.200	25.000	13.500	53.100	200.000

Table 8 shows the results of an analysis of the bacteriological parameteres of samples obtained from S3. The results clearly show a presence of only aerobic mesophelic bacteria in all of the samples.

Table 8. Results of the a bacteriological analysis of the water samples obtained from S3 (Lipkova River at village's entrance).

Bacteriological parametres	Units of measurement	May	June	July	August	Maximum levels allowed
Possible number of coliform bacteria	Nr. of bact./100ml	None	None	None	None	-
Fecal coliform bacteria	Nr. of bact./100ml	None	None	None	None	-
Aerobic mesophelic bacteria	Nr. of bact./100ml	1.000	2.000	2.000	2.800	-
Faecal streptococcus	Nr. of bact./100ml	None	None	None	None	-
Proteus species of bacteria	Nr. of bact./100ml	None	None	None	None	-
Sulphur-reducing bacteria	Nr. of bact./100ml	None	None	None	None	-
Pseudomonas aeruginosa	Nr. of bact./100ml	None	None	None	None	-
Escherichia coli	Nr. of bact./100ml	None	None	None	None	-

Discussion

Any high concentration of chemicals in water ecosystems represents pollution that can have undesired consequences for humans and the aquatic biota [14]. Ecosystems can be polluted by anthropogenic activity, as well as natural factors [15] [16].

The pollution of surface and underground freshwater is a serious problem since they are sources of drinking water and provide a living environment to aquatic biota. The sources of water pollution are natural and anthropogenic [17][18].

Areas that have not been polluted by anthropogenic activity may be polluted by animal waste, plants and soil. [19]. Pollutants contain organic and inorganic substances.

Human activity leads to a greater concentration of chemicals in aquatic environments, especially heavy metals and organic micro pollutants (pesticides, polychlorinated biphenyl, chlorinated organic substances, polycyclic aromatic hydrocarbons, etc.) by emissions of solids, liquids and gases from urban, industrial, agricultural and mineral sources. These pollutants present a danger to aquatic ecosystems and humans. The toxic effects are caused when the concentration of heavy metals exceeds permitted levels.

Surface waters polluted by human and animal fecal matter can transport pathogenic microorganisms, such as bacteria and viruses and this type of pollution is more common in densly-populated areas [20].

An analysis of the physico-chemical and bacteriological parameters of water samples obtained from Lipkova River and artificial Lake (System 1) has shown above normal levels of certain physic-chemical parameters. The data gathered from other references [17] [18] [19], leads us to believe that the increased turbidity of the water could be a result of the suspended particles of silt, soil, etc., which entered the river during the frequent rainstorms in this period. An indicator of this is the high level of suspended substances in the water samples and the consumption of $KMnO_4$. The high levels of ammonia, nitrites and nitrates are likely due to the entrance of human and animal waste into the river and lake also during rainstorms, but sewage pipes as well. In addition to the high levels of these parameters, the study has shown high levels of manganese, lead and copper. It is likely that the high levels of manganese and lead found in samples from S1 and S2 originate from the soil since these two areas are free of anthropogenic pollutants, whereas the high levels of copper, lead and detergents found in samples obtained from S3 are a result of anthropogenic factors since various objects containing these chemicals were found along the riverbank, as well as discharges of sewage into the river.

Conclusion

Based on the results of an analysis of the physico-chemical and bacteriological paramaters, water safety rules, and a classification [21], the folloing conclusions were reached:

- The water samples obtained from S1 are classified as III and IV given the high level of turbidity, dissolved oxygen, $KMnO_4$, manganese and lead found in them.
- The water samples obtained from S2 are classified as III given the high level of turbidity, dissolved oxygen, $KMnO_4$, suspended substances and lead found in them.
- The water samples obtained from S3 are classified as V given the high level of turbidity, suspended substances, $KMnO_4$, amonia, nitrates, nitrites, copper, lead, and detergents and lead found in them, whereas they are classified as III relating to the amounnt of dissolved oxygen.
- The results of a bacteriological analysis of the water samples obtained from the three sites have not found any contaminiants.

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