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Review Article

A Review on Consequences of Pollution of Some Indian Major Rivers and Their Remedial Measures

A.K. Panigrahi[1], Subasini Pattnaik[2]

[1]Ecotoxicology, Fisheries and Aquaculture Extension Laboratory, Department of Zoology, University of Kalyani, Kalyani, Nadia, 741235, West Bengal.
[2]Department of Zoology, Berhampur University, Berhampur, BhanjVihar, Odisha

Corresponding Author: A.K. Panigrahi

ABSTRACT

In India Rivers are divided into two parts like, north Indian River and south Indian River. Some north Indian rivers are Indus, Ganga, Gomati, Damodar, Rihand, etc. Some south Indian rivers are Mahanadi, Godavari, Krishna, Cauvery, etc. In India, river plays an important role. Many people directly or indirectly dependent on rivers. Rivers not only important to human it is also important to animals and plants. Because river act as most biodiversity rich area. But nowadays Rivers become polluted by various ways. Mostly occurred by industrial effluents and heavy metals contamination. Metal directly or through drain enter into rivers. Metals like, Fe,Hg,Cd, Pb, Zn cause most pollution in rivers. Beside sewage water directly fall into rivers and ultimately pollutes river. This paper contains cause of river pollution, effects of river pollution and remedial measure of river pollution.

Key words: *Heavy metals, Pollutants, Pesticides, Runoff, Anaemia, Food chain.*

INTRODUCTION

Water is essential for all aquatic and terrestrial animals and plants. Organic pollutants and heavy metals are the major source of pollutants in river (Goldar and Banerjee 2004). Chemical aspects and their interactions in polluted water had been discussed in the work of Dugan (1972). In river sources of Zn are painted idols immersion and electroplating industries (Boxallet al., 2000; Dean et al., 1972).There is a close relationship between Chemical oxygen demand (COD) and water and dissolved Oxygen act as an indicator of water pollution by Sharma (2018). Gandak river pollution at Samastipur was studied by Hakim (1984).Main source of river water pollution are organic pollutants and runoff from agricultural waste (Malik et al., 2014).Main cause of Gomti river pollution are domestic waste by Srivastava (2009). Singh and others (1997) report that due to heavy metals river Gomati sediments around the Lucknowurban centre are polluted. Most polluted river in India is Yamuna River and many industries are located on the bank of rivers (Malik et al., 2014). Son River water pollution mainly occurred by Paper Mill effluents and thermal power plant effluents (Ahirwar et al., 2015). Mula river pollution was reported by Sahu and others (2015).Fly ash-derived from river sediments was studied by Chander and others (1994).Due to municipal effluents, industrial effluents, agricultural runoff water quality is deteriorating in river (Akbal et al. 2011). Poor water quality reduces biodiversity (Cao et al., 1996).To maintain quality of the river water Sewage treatment plants have been constructed (CSE India, 2007). From these Sewage treatment plants untreated sewage is discharged directly into the river (CSE India, 2007). Due to many problems like, maintenance issues, these Sewage treatment plants are unable to operate properly and it is the major threat to river water quality (Malik et al., 2014) .River pollution affects food web and hamper public health (Ahirwar et al.,2015).

SOURCE OF POLLUTANTS IN RIVER:

Generally pollutants comes from,

1) Agricultural wastes: Pesticides & fertilizer runoff
2) Wastes from rituals: Organic wastes & chemicals
3) Domestic waste: Swashing of fertilizer bags & pesticide, soap, detergent, washing cattle, cow dung, container
4) Pharmaceuticals & other industries: Chemicals

WATER QUALITY PARAMETERS:

The aquatic ecosystems depend on the natural calamity of the water bodies. So, the each and every parameters of the water gives a sustainable life of aquatic organisms. The pH of the water indicate the acidic or basic, the dissolved oxygen and free carbon dioxide are correlate to the pH of the water. Here given table shows that the condition of some river of Indian continent.

Table -1: Survey result of Sabarmati river shows highly polluted

Sl no	Parameter	Results (Sample taken from Sabarmati river)	Standard (Inland surface water)
1	pH	6.75	5.5 - 9
2	Total suspended solids	530.00 mg/l	100 mg/l
3	Total dissolved solids	367.00 mg/l	NA
4	C.O.D	720 mg/l	250 mg/l
5	B.O.D	288 mg/l	30 mg/l
6	Oil& Grease	8 mg/l	10 mg/l

Source: CPCB2014,Survey of Sabarmati River carried out by ParyavaranMitra

Table -2: Sewage Waste management in the river Ganga

	2009	2012
Sewage generation (MLD)	2638	2732
Treatment Capacity (MLD)	1174	1208
Gap (MLD)	1464	1514
% Gap :Treated VS Untreated	55	55

Source: CPCB 2009 and 2013

Table -3: River Ganga Sewage treatment plants

State	No of Sewage treatment plants inspected	Installed capacity	Actual utilized capacity	Total no of Sewage treatment plants not in operation	Sewage treatment plants exceeding BOD/COD limits
Uttarakhand	4	54	-	0	2
Uttar Pradesh	8	358	287	1	4
Bihar	5	140	100	1	1
West Bengal	34	457	214	13	3
Total	51	1009	602	15	10

Source: CPCB, Pollution Assessment: River Ganga, Central Pollution Control Board MoEF July 2013.

SOME MAJOR RIVERS IN INDIA:

Yamuna river: From Yamnotri glacier, Yamuna river originates and this river covers Rajasthan, Uttar Pradesh , Himachal Pradesh , Delhi , Haryana , Madhya Pradesh (Ravindra et.al,2003) .On the banks of Yamuna river electroplating industries are situated and high amount of Cr directly fall into this river (Malik et.al, 2014) . Metals enter the environment through aquatic life systems surrounding the river and make a big threat to human health. (Malik et.al, 2014).Jain (2004), in a metal fractionation study of bed sediments of the river Yamuna,

Brahmaputra river: By discharge, Brahmaputra river is the largest river in world and in Tibet this river is known as Tsangpo (Borthakur et al.,2016). Guwahati city is situated on the bank of river Brahmaputra (Borthakur et al.,2016) .In Brahmaputra river, mean PH is 9.37 , mean

DO is 10.76 mg/l, (Kotoky and Sarma, 2017). The main cause of this river pollution are discharging of sewage, washing of clothes, agricultural runoff and specially municipal runoff that pollutes the river daily (Kotoky and Sarma, 2017). Crude oil also pollutes river Brahmaputra (Kotoky and Sarma, 2017).

Son river: Son river originates from Amarkantak Plateau and this river is tributary of river Ganga(Sinha and Sharma ,2003) .Main cause of Son river pollution are metal pollution (Ahirwar et al., 2015).In Son river TDS, hardness are found more than permissible limit (Ahirwar et al., 2015).In river Son, mean PH is 7.194, mean TDS is 898.5mg/l, mean Fe is 0.2484 mg/l, mean Cr is 0.0026, mean Mg is 14.5 mg/l, meanNa is 76.24 mg/l (Ahirwar et al., 2015)

Brahmani river: In Brahmani river, mean pH is 7.6, mean fluorine is 0.49 mg/l , mean alkalinity 48.48 mg/l, mean nitrate is 4.18 mg/l (Nath et.al, 2018) .This river is polluted day by day. Main cause of Brahmani river pollution are anthropogenic activities and agricultural runoff, industrial discharge and turbidity, Nitrate are found more than permissible limit and it affects fish diversity (Das et al., 2016)

Mahanadi River: This river rises in Chhattisgarh basin. Cuttack city is located on the bank of Mahanadi delta(Unni and Pawar 2000).Main cause of Mahanadi river pollution are domestic waste discharge, Rourkela steel plant effluents, biomedical waste(Panigrahi and Patra2013).Water of Mahanadi River turning towards eutrophication (Das and Panda2010) .Low diversity of plankton is observed in Mahanadi River (Panigrahi and Patra 2013). In the polluted area of Mahanadi, Cyanophyceae are found in large number while Chlorophyceae are found very less number (Panigrahi and Patra 2013).

Ganga River:

Levels of coliform bacteria in River Ganga are in excess of 2 lakh (Mallikarjun Y (2003). 260 mld of industrial wastewater, 9000 tonnes of pesticides used within the Ganga basin for agriculture purpose, solid waste, directly enter into the river every day (Srivastava et al., 2016). In River Ganga, season wise COD value varies from 12.5 mg/l to 65 mg/l (Srivastava et al., 2016). High amount of COD in River Ganga indicates contamination of water though domestic sewage and other effluent (Srivastava et al., 2016). In River Ganga season wise variation of chloride from 14 mg/l to 25 mg/l. (Srivastava et al., 2016). In protein metabolism sulphate is essential components (Srivastava et al., 2016). Concentration of sulphate varies season wise are 25 mg/l to 38 mg/l (Srivastava et al., 2016). Total hardness in river Ganga varies from 114 mg/l to 184 mg/l. (Srivastava et al.,2016). In Kanpur River Ganga is highly polluted due to discharge of sewage and industrial discharge plating industries. (Srivastava et al.,2016). A study reveals that in 2006 river Ganga had demonstrated coliform counts up to 100,000,000 MPN per 100 ml and BOD levels averaging over 40 mg/l in Varanasi (Agarwal, 2015) . High levels of mercury present in some fish muscles in Ganga river (Agarwal, 2015)

Cauvery river: Cauvery river rises from Brahmagiri hill (Mathivananet .al, 2005). PH value in Cauvery river varies from 6.5 to 9.4(Begum et al., 2008). In Salem district due to highly discharge of industrial effluents the planktonic population is highly influenced (Mathivanan et .al, 2005). Various types of heavy metals have been identified in Cauvery river, like Cr, Co, Cu, Mn, Ni, Zn, Pb(Begum et al.,2008). In river water high amount of Pb has been identified and high amount of Co has been identified in plankton which is presence in Cauvery river (Begum et al.,2008).

Gomti river: Gomti river, carries pollution load from industrial wastes and agricultural areas of eastern Uttar Pradesh (Gupta and Subramanian, 1994). Riverine suspended load have important role of buffering heavy metal concentrations by adsorption or precipitation (Fo¨restner, U., Mu¨ller, 1973). In river Gomti, bacterial contamination were observed with over 83 coliform/100 ml (Singh et al., 2005) . In Gomti river water samples, concentrations of Cadmium and copper were found negligible while other metals, like Cr,Fe,Mn, Ni, Pb, Zn were found in the range of Cr 0.0013–0.0057 mg/l, Fe 0.034–0.117 mg/l (Singh et al., 2005) . Average total Concentrations found for trace metals in the sediments are Cd 0.34–8.38 mg/g, Cr 2.22-19.13 mg/g, Cu 0–35.03 mg/g, Fe 1606–3142 mg/g, Mn 82.6–263.1 mg/g, Ni 6.5–29.8 mg/g, Pb 6.3–75.3 mg/g and Zn 3.1–101.7 mg/g (Singh et al., 2005) . Heavy metals concentrations in sediments were found higher than those obtained in river water (Singh et al., 2005).

Chambal River: Metal effluents discharges into rivers cause dangerous effects to the health (Tavares and Carvalho, 1992). In environment metals are released by natural processes and anthropogenic sources, (Reddy and Baghel, 2010). Magnesium, calcium, manganese and iron contribute hardness of water (Shrivastava and Patil, 2002). Barrett (1953) has reported that soft waters are less productive than hard waters from fisheries point of view .In Chambal river BOD value from 0.60 mgl-1 - 5.67 mgl-1, dissolved oxygen (mgl-1) 4.86-14.59, free carbon dioxide (mgl-1) 0.00-16.50, total alkalinity (mgl-1) 70.00-290.00, total hardness (mgl-1) 42.00-140.00, chlorides (mgl-1) 15.62-80.94, Turbidity (NTU) 1.00-178.00), electrical conductivity (µS cm-1) 100.00-884.00, Total dissolved solids (mgl-1) 260.00-500.00, pH 7.6-9.33, ammonia (mgl-1) 0.00-0.56 1, sodium (mgl-1) 14.30-54.40 (Saksena and Rao, 2008)

Bandi River: The textile dyeing situated at Pali has been discharging wastes effluents in the Bandiriver (Rathore 2011). Bandi river Water quality is severely polluted (Rathore 2011). Water quality deterioration has adverse effect on human beings and also aquatic ecosystem (Chinda et al. 2004; Ugochukwo 2004; Emongor et al. 2005). Textile dyeing industries depend on groundwater and chemical analysis results of sample waters reveal that industries uses alkaline groundwater of electrical conductivity varies from moderately to fresh saline (Rathore, 2012) . Textile industries have production capacities ranging between 725 (10,000 m) to 3625 kg (50,000 m) of cloth / day and requirement of water varying from 30 to 275 m3/day and averages 120 m3/day. Wastewater volume varies from unit to unit and ranges from 41 to 76 L/ kg of cloth processed with average of 55L/kg (Rathore, 2012) .

Periyar River: Periyar river water is slightly acidic nature. In river Periyar dissolved oxygen is in the permissible limit (BIS 10500-1991: 5-6 mg/l) except several sampling sites. Water is high conductivity which may cause due to the presence of high ions concentration in the river. Nitrate-n concentration in river Periyar is within the permissible limit (BIS 10500-1991: 45mg/l).COD, fluoride; phenol, total dissolved solids, and iron present in river Periyar are well above the permissible limit. Sulphate, chloride, total hardness, Magnesium has concentrations within the permissible limit (E and Madhu. 2014). Overall water quality index of periyar river was calculated as 24.76 which is categorised as ‘poor’ water class (index value between 0-45) (E and Madhu. 2014). In the downstream of river water quality index is reduced (E and Madhu. 2014).

Mithi River: In River Mithi many elements are normally present in low concentrations (Singare et al., 2012). Heavy metals are a type of trace elements that create definite health hazards when it is taken up by plants (Singare et al., 2012). Group of heavy metals includes, Cr, Cd, Ni, Zn, Cu, Pb, Fe, etc (Singare et al., 2012). Aluminium concentration present in river Mithi River ranging from 5-61, 11-182 and 8-213 µg/Lat different sampling stations (Singare et al., 2012). Cr concentration present in river Mithi river ranging from 9-212, 6-414 and 16-455 µg/L at different sampling stations (Singare et al., 2012). Hg concentration present in river Mithi River ranging from8-281, 5-60 and 3-31 at different sampling stations (Singare et al., 2012).

Kali River: Toxic elements enter into aquatic environment through a variety of routes therefore; it affects human health (Bao et al., 2012). Heavy metals like Pb, Mn, Fe and Cr cause dangerous effect to aquatic ecosystems and human health (Panakkal and Kumar, 2014). Heavy metal concentration of Kali river are, Fe in Pre-monsoon 1.77±0.87 and Post-monsoon 1.53±0.75, Cr in Pre-monsoon 0.09±0.03 and Post-monsoon 0.06±0.02, Cd in Pre-monsoon 0.08±0.03 and Post-monsoon 0.06±0.03, Zn in Pre-monsoon 29.71±7.59 and Post-monsoon 24.71±6.42, Pbin Pre-monsoon 0.19±0.13 and Post-monsoon 0.13±0.07 (Mishra et al., 2015)

Narmada River: Water quality is deteriorated mainly by human activities like, discharge of industrial effluents, disposal of dead bodies, sewage wastes which may cause ecological damage and also serious health hazards (Meitei et.al. 2004). In agriculture, many fertilizers are used and these fertilizers also contribute to river pollution because rainwater drains these chemicals directly into the rivers (Katakwar, 2016). In Narmada river adjacent area local people suffering from a various health problems like, gastric ulcers, skin problems, diarrhoea, stomach problems (Katakwar, 2016). People lives surrounding the area also suffering from respiratory problems and also odor pollution (Katakwar, 2016).

Damodar river: In this country most polluted river is Damodar river (Banerjee et al.,2003). Different industrial health hazards, bacteriological pollution, Chemical pollution cause Damodar river pollution (Banerjee et al .,2003). In Damodar water, coliform bacterial count is higher due to waste disposal from cement, coal-washing plants and other industries (George et al., 2010). Due to this chemical oxygen demand, dissolved and suspended solids, hardness are high (George et al., 2010). In Damodar pH of the water varied from 7.4 to 8.0 in summer and 7.8 to 8.9 in monsoon (Banerjee and Niyogi). In summer range of hardness values varied from 133 mg/L to 327 mg/L (Banerjee and Niyogi**).** In summer conductivity varies between 59 mmhos/cm to 78 mmhos/cm and in monsoon it varies from 94 mmhos/cm to 140 mmhos/cm (Banerjee and Niyogi).In summer, Chromium level varies between 30µg/L to 146 µg/L and in monsoon it varies between 67 µg/L to 160 µg/L (Banerjee and Niyogi**)**. In summer copper level varies between 10 µg/L 36 µg/L and in monsoon it varies from 14 pgd to 56µg/L (Banerjee and Niyogi). In summer, lead level varies between38 µg/L to 96 µg/L and in monsoon it varies from 67 µg/L to 146 µg/L**.** (Banerjee and Niyogi)**.**

Mathabhannga river: In August the range of pH was 6.6 and in February it was 8.2(Chandra and Panigrahi, 2014). This indicates water was acidic and alkaline in nature (Chandra and Panigrahi, 2014). PH value was minimum due to rainfall in monsoon (Chandra and Panigrahi, 2014). DO was maximum in winter because of less degradation and least DO was found in May 4.5mg/l (Chandra and Panigrahi, 2014). The Hardness value was minimum in December as 172mg/l and maximum was in June 272 mg/l (Chandra and Panigrahi, 2014). Higher TDS concentration was in summer but lower in January (Chandra and Panigrahi, 2014). Nitrate was rich in October 2.04mg/l and least in August1.45mg/l (Chandra and Panigrahi, 2014). The COD value maximum in September 602 mg/l and the minimum in January 411mg/l (Chandra and Panigrahi, 2014)

Mula River:

In Pune city, Mula is the major river. Water quality of river Mula was studied by Patwardhan et al. (2003). In Mula River Dissolved Oxygen is maximum in monsoon 4.05±2.03 mg/L to 6.60± 2.14 mg/L(Kshirsagar and Gunale, 2011).Concentration of low dissolved oxygen in fresh water indicates high pollution level in water and causes negative effects on aquatic life (Yayintas et al., 2007). Free carbon di oxide concentration in Mula River was recorded highest during summer 39.47±1.96 mg/L and minimum was recorded in winter 10.63 ± 1.63 mg/L. (Kshirsagar and Gunale, 2011) .Free carbon di oxide concentration in Mula river is higher as compared to fresh water bodies. (Kshirsagar and Gunale, 2011). In River Mula , minimum biological oxygen demand (BOD) was 59.78 ± 13.18 mg/L and maximum BOD was during summer 121.31 ± 5.89 mg/L (Kshirsagar and Gunale, 2011). pH of Mula River water shows slightly alkaline 7.11±0.26 to 7.74±0.06(Kshirsagar and Gunale, 2011). In Mula River chloride concentration was maximum during summer and also in winter. In summer, Concentration of chloride was considerably higher 75.64±5.54 mg/L due to reduced flow of waste (Kshirsagar and Gunale, 2011). Munawar 1970, reveals that chloride level high due to domestic waste. Mean nitrate values in Mula River were 3.83 ± 1.17 mg/L to 21.75±3.08 mg/L (Kshirsagar and Gunale, 2011). Nitrates concentration decreased as rainfall increased (Ajibola et al., 2005). As per WHO guideline standard drinking water quality for nitrate is 45 mg/L.

Musi River:

In Musi River total alkalinity ranging between 324 mg/l to 112 mg/l (Cheepi, 2012). Total Hardness in Musi River ranging between 248 mg/l to 306 mg/l (Cheepi, 2012). Calcium concentration in Musi River ranging between 160 mg/l to 174mg/l (Cheepi, 2012). Nitrate concentration in Musi River is 81g/l to 74g/l (Cheepi, 2012). High level of nitrates causes methmoglobia, in fishes and other aquatic organism (Cheepi, 2012). Chloride concentration in Musi River varies between 148 mg/l to 212 mg/l (Cheepi, 2012). Alkalinity of Musi River ranging from 324 mg/l to 112 mg /l (Cheepi, 2012). Chemical Oxygen Demand in Musi River varies between 128 mg/l to 12 mg/l (Cheepi, 2012). Cost of health hazard, loss in agriculture, loss of employment, agricultural land damage occurs due to Musi River pollution (Cheepi, 2012).

Kulti River: Heavy metals concentration (mg/l) in Kulti Rivers are, Cr 1.09 ±,Pb0.23 ±, Zn 0.50, Cd ± 0.01(Akhand et al., 2012) . Industrial sector released effluents pass through the drainage system to the Kulti River (Akhand et al., 2012). Kulti river lock gate act as the exit point of all wastes of the city that is generated by industrial wastes and anthropogenic activity (Mitra& Gupta 1999).Contaminants of river water occurs by mainly sources,(1) municipal and industrial wastewater effluents (2) diffuse sources such as metrological factors (Akhand et al., 2012)

Effects of river pollution:

Water quality degradation occurs due to coal mining and thermal power plants effluents (Das et al., 2016). Organic pollutants affect richness of macro invertebrate taxa (Xu et.al, 2013). Water pollutants induced stress affects blood cell injury and disrupted haemoglobin synthesis occur in fish (Mckim et al., 1970; Gross et al., 1975).Anaemia occurs due to disrupted haemoglobin (Mckim et al., 1970; Gross et al., 1975).The reduction in haemoglobin content in the fish is reduced due to inhibitory effect of toxic substance by Pamila et al.,(1991). In the fish body, after entering the pollutants are slowly accumulated (Newman and Mitz., 1988; James and Sampath, 1996; James et al., 1996), and parameters of blood affected due to pollutant toxicity. Polluted water enters into fish body and accumulated in various organs like liver and kidney (Al-Mohanna, 1994). Metallic ions cause physiological abnormalities in fish (Singh and Tandon 2009). River pollution also affects human health and cause several diseases (Ahirwar et al., 2015). Pollution of river devastating fish, animals and birds (Panigrahi 2012). Contaminated water reduce reproductive capability of animals (Panigrahi 2012). In presence of petroleum effluents fecundity index and maturity index also reduced (Panigrahi and Konar, 1992). Due to effects of petroleum effluents, survival, behavior, growth are altered (Panigrahi and Konar, 1992). Abnormal behavior occurs due to decreased respiratory efficiency (Saha and Konar, 1986). Petroleum effluents on river affect benthic organisms (Panigrahi and Konar, 1989). Some zooplankton like *Cyclops viridis* shows erratic and lethargic movement due to petroleum pollutants (Panigrahi and Konar, 1989). *Thiaratuberculata,* a type of gastropod shows huge secretion of mucous due to petroleum effluents (Panigrahi and Konar, 1989). Due to river pollution by petroleum and detergents, fish olfactory organs are damage that lead to inability to identify food (Panigrahi and Konar, 1990). Monocrotophos, an agriculture pesticides highly toxic to *Cyprinuscarpio* and it cause river pollution (Panigrahi et al., 2014). Discharge of metals into river cause several hazards of fishes (Bakshi and Panigrahi, 2012). Nabaganga River pollution maily occur by anthropogenic activity (Biswas and Panigrahi , 2014)

Remedial measures of river pollutions:

Solid wastes should be disposed after treatment and must be banned plastic bags (Srivastava, 2014). Industrialists should responsible that water must be treated before falling into river (Srivastava, 2014). Increase Community awareness programme (Das et al., 2016). Before reaching the pollutants into river the drainage water should be treated and proper management requires those drains directly enter into the river (Sadhana and Raj, 2013). Must be installed sewage treatment plant and after treatment this water should be used for domestic purpose (Sadhana and Raj, 2013). For evaluation of contamination quality of waste water effluent must be checked time to time (Lokhandeet .al, 2011). Plastic bags should be avoided (Panigrahi 2012). Always clean up beaches and also waterways (Panigrahi 2012). Proper disposal of toxic chemicals should be maintained (Panigrahi 2012).

CONCLUSIONS

India is river rich country. River is the main lifeline of this country. Many cities are located on the bank of rivers. River plays crucial role for biodiversity. In river food chain occurs by algae, small animals, insects, small fish and large fish. But the pollution of river is increasing day by day. Pollution occurs by not only discharge of effluents but also various anthropogenic effect. Heavy metals such as Pb, Cd, and Zn enter into fish body. Due to pollution poor water quality of river is shown. Pollution affects whole biodiversity on aquatic ecosystems. Many fishes are died due to effects of heavy metals pollution on river. Due to discharge of heavy metals contamination eutrophication occurred. Many species of river are extinct due to pollution and ultimately it leads to loss of biodiversity. Plantation of trees on the bank of river is the effective solution to reduce river pollution. To overcome river pollution plastic should be banned as it affects food chain. If we not aware about river pollution in future it will seriously affect human population.

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