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Research Article

INFLUENCE OF TEMPERATURE ON PHYSICO-CHEMICAL PROPERTIES OF FRESHWATER ECOSYSTEM OF BUNDELKHAND REGION OF UTTAR PRADESH, INDIA

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Abstract

Several studies have been conducted on the analysis of physico-chemical and biological parameters in large number of aquatic ecosystems in recent past. The more scientific method of assessment of water quality is to develop correlation between different physico-chemical parameters, which could be helpful in the interpretation of the observed data and estimation of the pollution load and show their relationship with a single parameter to other parameters on a scientific basis. Temperature is one of the important physical parameter which is directly affected to all physico-chemical properties. It is also one of the crucial limnological parameters that play a significant role in regulating the water quality as well as the productivity of the ecosystem. Present study try to focus on the develop correlation between temperature and some other physico-chemical parameters of the aquatic eco-system of Bundelkhand region as a preliminary investigation. During the study it was found that temperature is significantly positive (+) with pH, EC, Alkalinity, Nitrate , Turbidity, Total Solid, Total Dissolved Solid , Total Suspended Solid, Total Hardness, Bio-chemical Oxygen Demand and Chemical Oxygen Demand but showed negative (-) with Dissolve Oxygen , and Fluoride content.

Keywords: Correlation, water Temperature, Physico-chemical Parameters, Bundelkhand region.

Introduction

Water temperature is a physical property expressing how hot or cold water is. As hot and cold are both arbitrary terms, temperature can further be defined as a measurement of the average thermal energy of a substance. Thermal energy is the kinetic energy of atoms and molecules, so temperature in turn measures the average kinetic energy of the atoms and molecules [1]. This energy can be transferred between substances as the flow of heat. Water temperature has been defined as the “abiotic master factor” due to its effect on aquatic organisms [2]. Temperature could be an important factor to consider when assessing water quality. In addition to its own effects, temperature influences several other parameters and can alter the physical and chemical properties of water. In this regard, water temperature should be accounted for metabolic rates and photosynthesis production, toxicity, dissolved oxygen(DO) and other dissolved gas concentrations, conductivity and salinity, oxidation reduction potential (ORP), pH, density [3]. In addition to its effects on aquatic organisms, high water temperatures can increase the solubility and thus toxicity of certain elements [4]. These elements include heavy metals such as cadmium, zinc and lead as well as compounds like ammonia [5]. Water temperature can not only increase the solubility of toxic compounds, but it can also influence an organism’s tolerance limit. Mortality rates due to zinc are significantly higher at temperatures above 25°C than at temperatures below 20°C [6].Temperature is important factor affection the aquatic chemistry and biological processes of the organisms dwelling therein. A rise in temperature of the water leads to an increase in the rate of chemical reaction in water besides reducing the solubility of gases [7]. Temperature affect in comprehensive process which developed in the natural waters such in the life of organism. Especially it affect in the dissolution of oxygen and another gases in water [8]. Temperature is most

important for fish and other aquatic life in lake. Temperature can vary greatly throughout the lake, with surface water affected more by air temperature than deeper water. Thus the top of the pond will be slightly warmer in the summer and colder in the winter than deeper portions of the pond. Water temperature is also important when using aquatic herbicides to treat plant or algae growth. Most aquatic herbicides are most effective when water temperatures are between 15.5^0C and 23.8^0C [9].

Materials and Methods

Study area

The Bundelkh and massif covers about 26000 sq. km. of the total area of the southern Uttar Pradesh and north-eastern Madhya- Pradesh in central India and forms the northern fringes of the Peninsular Indian shield. Jhansi is one of the most important historical city of this region of Uttar Pradesh and covers an area of 45.22 sq. km. The study area lies between $25^0$27'4" N to $25^0$28'4" N latitudes and $77^0$38'28" E to $77^0$40'12" E longitudes. The river Betwa which is selected for present investigation originates from Raisen district of Madhya Pradesh near Barkhera village south-west of Bhopal at an elevation of about 576 meter above mean sea level. Total length of the river from its origin to confluence with the Yamuna is 590 km. (232 km in Madhya Pradesh and 358 km. in Uttar Pradesh). It enters into Uttar Pradesh near village Bangawan of Jhansi district. Betwa river is located in the east of Jhansi city. Monthly water sample have been collected from 3 different point of Betwa river around Jhansi city (about 5 km stretch) as fallows- Site-1: Kachacha Ghar; Site-2: Orchcha resorts and Site-3: Knot ghat.

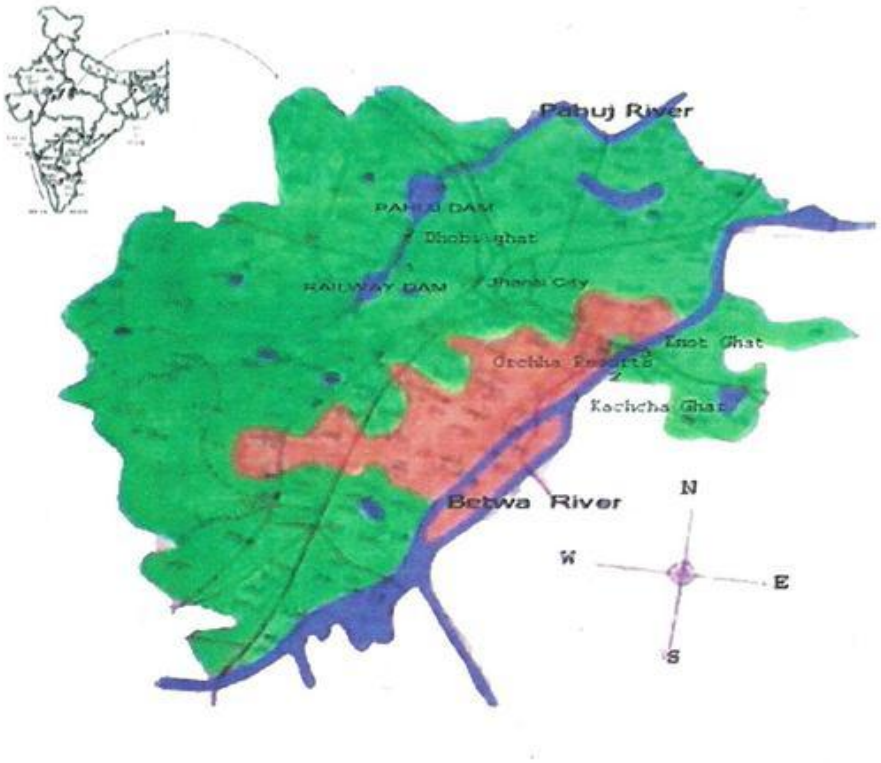

Figure – 1 : Shows the selected study sites.

Analytical techniques

The analytical work of the collected samples was done by the HIMEDIA (WTO-23) Octo Aqua Test Kit (multi-parameter) as well as laboratory testing- used to APHA guideline 2005 [10]. The statistical analysis facilitate the evaluation of some in addition to finding correlation among parameters, it provides a fairly accurate idea about the quality of the surface water.

The correlation co-efficient 'r' was calculated using the equation [11].

$$r = \frac{N\sum (XiYi)-(\sum Xi).(\sum Yi)}{\sqrt{[N\sum Xi^2-(\sum Xi)][N\sum Yi-(\sum Yi)^2]}}$$

Where, Xi and Yi represents two different parameters.
N= Number of total observations

.

Results and Discussion

The physico-chemical characteristics provide a fair idea of the water quality in any water body. In the present study, correlation of physico-chemical parameters with temperature of surface- water have been summarized and presented in Table -1.

Water Temperature and pH :

pH is calculated by the number of hydrogen ions in solution. At a pH of 7, the hydrogen and hydroxyl ions have equal concentrations, 1 x 10^{-7} M, keeping the solution neutral. However, these concentrations only hold true at 25°C. As the temperature increases or decreases, the ion concentrations will also shift accordingly [12] as is explained by Le Chatelier's Principle. Any change to a system at equilibrium, such as adding a reactant or altering the temperature, will shift the system until it reaches equilibrium state again.

The equation: $H_2O=H^+ + OH^-$ is an exothermic reaction [13]. That means if the temperature of water increases, the equation will shift to the left to reach equilibrium again. A shift to the left decreases the ions in water, increasing the pH. Likewise, if the temperature were to decrease, the equation would shift to the right, increasing the ionic concentration and decreasing pH.

However, that does not mean that temperature changes will make a solution more acidic or basic. Because the ratio of hydrogen and hydroxyl ions remains the same, the acidity of water does not change with temperature. Instead, the entire pH range shifts, so that neutral water will have a value other than 7. Pure water will remain neutral at 0°C (pH is 7.47), 25°C. (pH is 7.00) or 100°C. (pH is 6.14). But, pH was recorded positive correlation (0.9356) with temperature in the present study may be due to presence of abundant macrophytes. Same trend was also recorded by [8; 14; 15] in their respective finding. The photosynthesis of weeds may cause the water into slightly higher alkaline wherever they present [16; 17]**.**

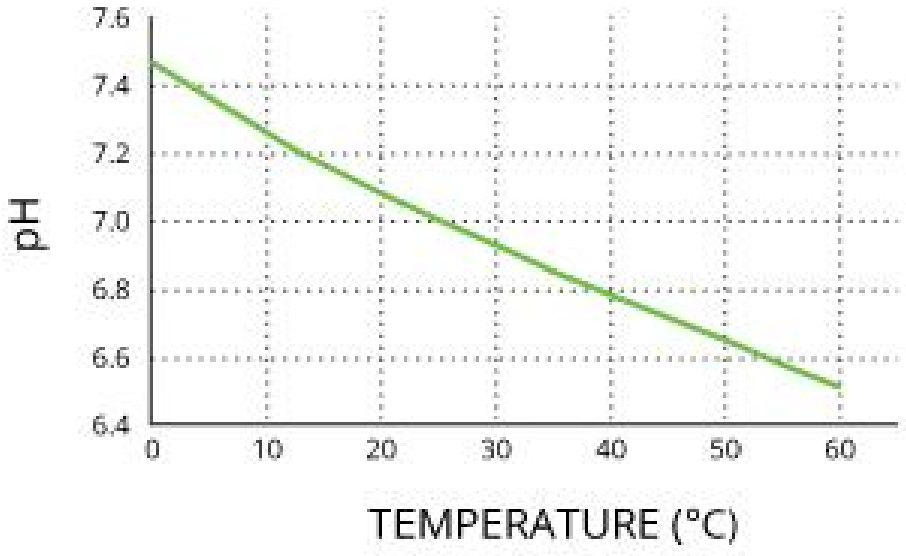

Figure – 2: Shows the relation between Temperature with pH [33]

Water Temperature and Dissolved Oxygen

The solubility of oxygen and other gases will decrease as temperature increases [18]. This means that colder lakes and streams can hold more dissolved oxygen than warmer waters. If water is too warm, it will not hold enough oxygen for aquatic organisms to survive.

During the present investigation it was found that the Dissolve oxygen was negatively correlated with temperature (-0.9445) that means DO decreases with increasing of temperature, same trend was also recorded by [19; 9].

Table No. 1: Correlation between different physico-chemical properties of the water with Temperature

Sl. No		Temp (°C)	pH	Conductivity (µs/cm)	Alkalinity (mg/l)	Total Hardness (mg/l)	Chloride (mg/l)	Nitrate (mg/l)	Dissolved Oxygen (mg/l)	Turbidity (NTU)	Total Solid (mg/l)	Total DS (mg/l)	Total SS (mg/l)	Fluoride (mg/l)	BOD (mg/l)	COD (mg/l)
01.	Temperature	1	0.93568	0.97340	0.98750	0.9015709	0.95446	0.95869	-0.94456	0.95689	0.91632	0.74627	0.98719	-0.48489	0.99270	0.91594
02.	pH	0.93568	1	0.92119	0.93301	0.9818439	0.98709	0.98979	-0.99735	0.99619	0.79085	0.51929	0.97478	-0.44106	0.92034	0.99480
03.	Conductivity	0.97340	0.92119	1	0.94731	0.8517927	0.94033	0.91654	-0.91641	0.94477	0.80674	0.6136	0.95268	-0.53190	0.95456	0.90758
04.	Alkalinity	0.98750	0.93301	0.94731	1	0.9224437	0.92953	0.9626	-0.94949	0.95748	0.92890	0.75435	0.98751	-0.57819	0.99805	0.92601
05.	Total Hardness	0.90157	0.98184	0.85179	0.92244	1	0.95162	0.98629	-0.98957	0.97495	0.81342	0.54630	0.9589	-0.44661	0.90227	0.98289
06.	Chloride	0.95446	0.98709	0.94033	0.92953	0.95162	1	0.98135	-0.98181	0.98354	0.81326	0.56829	0.97491	-0.34639	0.92600	0.96650
07.	Nitrate	0.95869	0.98979	0.91654	0.9626	0.98629	0.98135	1	-0.99661	0.99093	0.86725	0.62864	0.99100	-0.43991	0.95229	0.98008
08.	Dissolve Oxygen	-0.94456	-0.99735	-0.91641	-0.94949	-0.98957	-0.98181	-0.99661	1	-0.99626	-0.82568	-0.56602	-0.9834	0.4607	-0.93635	-0.99288
09.	Turbidity	0.95689	0.9961	0.94477	0.95748	0.97495	0.98354	0.99093	-0.99626	1	0.81741	0.56067	0.98661	-0.49856	0.94702	0.99273
10.	Total solid	0.91632	0.79085	0.80674	0.92890	0.81342	0.81326	0.86725	-0.82568	0.81741	1	0.93121	0.89826	-0.3934	0.93591	0.76272
11.	Total DS	0.74627	0.51929	0.61362	0.75435	0.54630	0.56829	0.62864	-0.56602	0.56067	0.93121	1	0.68767	-0.27947	0.77590	0.4786
12.	Total SS	0.98719	0.97478	0.9526885	0.98751	0.958911	0.97491	0.99100	-0.9834	0.98661	0.89826	0.68767	1	-0.49041	0.98327	0.96311
13.	Fluoride	-0.48489	-0.44106	-0.531906	-0.57819	-0.44661	-0.34639	-0.43991	0.4607	-0.49856	-0.3934	-0.27947	-0.49041	1	-0.55873	-0.51071
14.	BOD	0.99270	0.92034	0.954569	0.99805	0.90227	0.92600	0.95229	-0.93635	0.94702	0.93591	0.77590	0.98327	-0.55873	1	0.90863
15.	COD	0.91594	0.99480	0.9075848	0.92601	0.98289	0.96650	0.98008	-0.99288	0.99273	0.76272	0.4786	0.96311	-0.51071	0.90863	1

DS - Dissolved Solid; SS – Suspended Solid; BOD – Biochemical Oxygen Demand; COD – Chemical Oxygen Demand

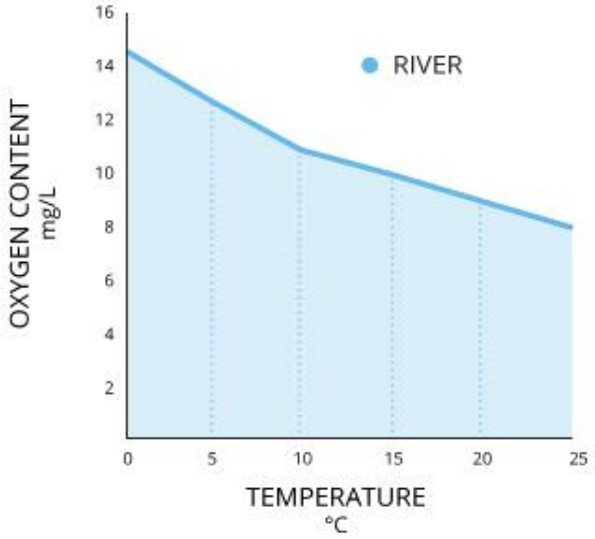

Figure – 3 : Shows the relation between Temperature with Dissolve Oxygen [33]

Water Temperature with Conductivity and TDS :

Water temperature can affect conductivity in two ways. As conductivity is measured by the electrical potential of ions in solution, it is affected by the concentration, charge and mobility of those ions [20].

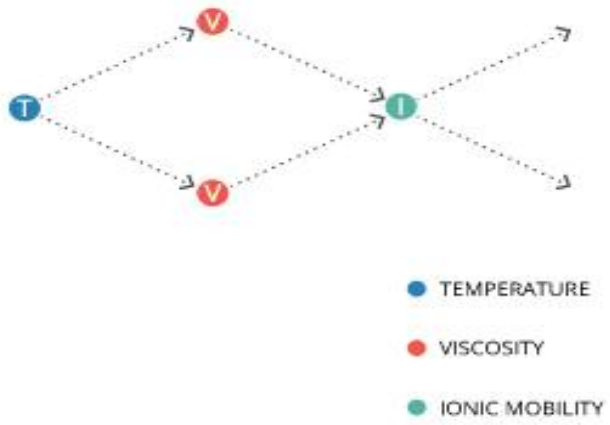

Figure – 4: Water temperature affects viscosity, which in turn affects ionic activity and conductivity [33]

Ionic mobility is dependent on viscosity, which is in turn dependent on temperature [21]. Viscosity refers to a liquid's ability to resist flow [22]. The inverse relationship between temperature and viscosity means that an increase in temperature will decrease viscosity [23]. A decrease in the viscosity of water increases the mobility of ions in water. As such, an increase in temperature increases conductivity. Conductivity increases approximately 2-3% per 1°C increase in temperature, though in pure water it will increase approximately 5% per 1°C [20]. This variation is why many professionals use a standardized comparison of conductivity, known as specific conductance that is temperature corrected to 25°C [24]. The rate at which conductivity increases is dependent on the salts present in solution. The solubility of KCl will increase from 28g KCl/ 100g H_2O at 0°C to 56 g KCl/100g H_2O at 100°C, while the solubility of NaCl only increases from 35.6g to 38.9g NaCl/100g H_2O over the same temperature range. In addition, it has been observed that there are a few salts that become less soluble at warmer temperatures, and thus will negatively affect conductivity (Figure – 5).

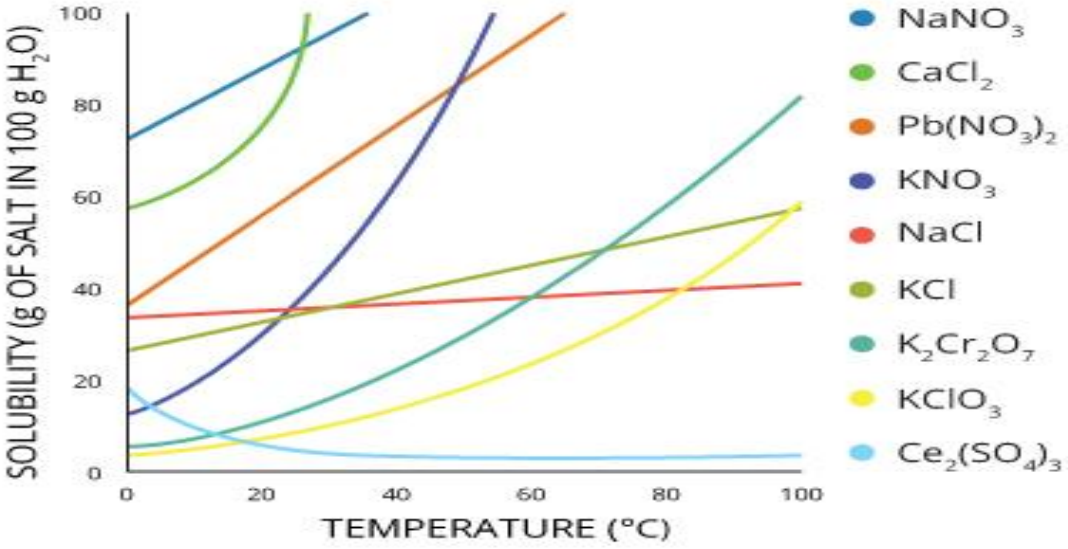

Figure – 5 : Shows the relation between Temperature with Solubility of Salts [33]

Many salts are more soluble at higher temperatures. As a salt dissolves in water, it breaks down into its respective ions. As warm water can dissolve several minerals and salts more easily than cold water, the ionic concentration is often higher [18]. The increased mineral and ion content can be noticed in natural hot springs, which tout their "healing" abilities [25]. These dissolved solutes are often referred to as Total Dissolved Solids or TDS [26]. TDS refers to all ion particles in solution that are smaller than 2 microns [24]. These salts and minerals enter the water from rocks and sediment in contact with it. Electrical conductivity (0.9734) and Total dissolved solid (0.7462) were also showed positive correlation with water temperature in our study.

Water Temperature with BOD and COD

Biochemical Oxygen demand determines the amount of oxygen required for biological oxidation of organic matter with the help of microbial activities. In the present investigation BOD is positive correlated with water Temperature (0.9927) same trend was recorded by [19; 27].

Chemical oxygen demand determines the amount of oxygen required for chemical oxidation of most organic matter and oxidizable inorganic substances with the help of strong chemical oxidant. In present investigation value of COD is positively correlated (0.9159) with water temperature. The source of COD in water bodies may be due to input of domestic drains and the use of soap and detergents for washing and bathing in and around anthropogenic activities.

Water Temperature and Hardness

Hard water is that having a high mineral composition (water with a low mineral content is known as soft water). This content usually consists of high levels of metal ions, mainly calcium (Ca) and magnesium (Mg) in the form of carbonates, but may include several other metals as well as bicarbonates and sulfate. It is not generally dangerous but certain studies found an influence of water hardness on the cardiovascular diseases and mortality [28; 29].

Water hardness usually measures the total concentration of Ca and Mg, reported as ppm w/v (or mg/l). Ca and Mg are the two most prevalent divalent metal ions. Although in some geographical locations iron, aluminum and manganese may also be present at elevated levels. Calcium usually enters the water from either $CaCO_3$ as limestone or chalk or from mineral deposits of $CaSO_4$. The predominant source of magnesium is dolomite, $CaMg(CO_3)_2$. The precise mixture of minerals dissolved in the water, together with the water's acidity (pH) and temperature will determine the behavior of the hardness, therefore a single number on a scale does not give a full description. A descriptions of hardness corresponding roughly with range of mineral concentrations is presented as: (1) Soft-0-20 mg/l as calcium (2) Moderately soft : 20-40 mg/l as calcium (3) Slightly hard: 40-60 mg/l as calcium (4) Moderately hard : 60-80 mg/l as calcium (5) Hard : 80-120 mg/l as calcium (6) very hard > 120 mg/l as calcium. Temporary hardness is hardness that can be removed by boiling [30]. During the present investigation Total hardness was observed as positive correlation with water temperature (0.9015) may be due to abundance of hard rock in this region.

Water Temperature and Nitrate

In aquatic ecosystems, nitrogen is present in different forms. The usable forms of nitrogen for aquatic plant growth are ammonia (NH_3) and nitrate (NO_3). Excess amounts of nitrogen compounds can result in unusually large populations of aquatic plants and/or organisms that feed on plants. For instance, algal blooms can be a result of excess nitrogen. As aquatic plants and animals die, bacteria break down the organic matter. Ammonia (NH_3 or NH_4) is oxidized, or combined with oxygen, to form nitrites (NO_2) and nitrates (NO_3).

The cycle for breaking down organic matter (both the biological process and the chemical process) uses up dissolved oxygen [31]. During the present study also Nitrate was recorded highest during peak summer and showed positive correlation with water temperature (0.9586).

Conclusion

Bundelkhand region of Uttar Pradesh in India is having semi-arid climate and experienced with extreme cold as well as maximum temperature during peak summer. Average minimum temperature varies from around 6^0 C to 12^0 C and maximum temperature varies from 38^0 C to 43^0 C. Actual local temperatures are much higher, due to local conditions such as lack of haze and radiation from rocky soils or outcrops. Banda is one of the hottest places in India, and several people die of sunstroke here every year. On June 14 and 15, 1995, day temperatures reportedly shot up to 52^0 C in Banda, resulting in hundreds of deaths within 24 hours. Violent local squalls of short duration are sometimes generated in summer. Generally hottest days are in May and coldest days in December or January. The lowest temperature recorded in the region is 0.6^0 C in Banda and Chhatarpur, in January 1962 [32].

Various studies showed that the fluctuating climatic conditions greatly affect the water quality by showing changes in their ionic concentrations. In present study also during summer season ions concentration in water have been increases due to increase in temperature as warm water can dissolve several minerals and salt more easily than cold water. Almost all the parameters except DO and Fluoride ions have shown positive correlation with temperature. So it can be concluded that temperature is one of the crucial parameter that play a significant role in regulating the water quality as well as the productivity of the aquatic ecosystems.

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