International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in

Vol.3., Issue.5., 2015
(Sept.-Oct.)

RESEARCH ARTICLE

ISSN: 2321-7758

SEASONAL VARIATION OF THE WATER QUALITY OF THE KRISHNA RIVER, WITH EMPHASIS ON THE USE OF THE SURFACE WATER RESOURCE

Dr. E V SURESH KUMAR[1*], P. PHEBE[2]
[1]Lecturer in Chemistry, SVKP College, Markapur, Andhra Pradesh
[2]Lecturer in Chemistry, G.R.R&T.P.R.Degree College, Cumbum, Andhra Pradesh
*Email: drevskchem@gmail.com

ABSTRACT

This article examines seasonal changes in the quality of the water resource of the river that supplies drinking water to the population of India. It is based on the quality indices of the Krishna River, which flows through the same-named basin and is close to the Vijayawada Municipality in Andhra Pradesh, India. This study examines the seasonal variation in water quality and how it relates to the pollution levels present throughout the year, with a focus on the increase in suspended particles from trawling during the rainy season. As sample locations to identify the variations in water quality, one in the upper Krishna River Basin (Chintapalli), another in the middle (Pondugula), a third in the lower (Chandarlapadu), and a fourth in the catchment region were established (Tallaya Palem). The WQINSF approach, which provides weighting values to each of the variables in those that are based on monthly samplings in which parameters were taken in situ and parameters that were examined at the laboratory level, was used to calculate water quality indices. These enabled us to identify the main contributors to the quality variances as being seasonal variations in electrical conductivity, nitrates, phosphates, dissolved oxygen, total solids, and total and faecal coliforms. The Krishna River's rainy season waters have medium-to-poor quality (quality indices of 40.21 to 60.21), making them appropriate for use in purification procedures. It lies within the same range that might be utilised for most crops, although treatments must be completed for use in irrigation systems within a few months. The combination of physical-chemical and bacteriological parameters (such as temperature, dissolved solids, turbidity, phosphates, % oxygen saturation, pH, nitrates, faecal coliforms, and BOD) could result in these results, it should be emphasised. The morphometry of the basin was also assessed, describing it as elongated and with low drainage density, showing a poorly drained area with a very slow hydrological response. It has an average slope of 43.21 percent and a slope of 5.72 percent for the main channel. The Krishna upper basin flow was found to be at its maximum in August (2.33 m^3/s) and lowest in February (0.001 m3/s in the bottom region of the basin).

Key Words: Surface water, water quality indices, basin, water analysis, water quality, water pollution, integrated water resources management, irrigation, seasonal variation, basin indices, BOD, dissolved oxygen, basin.

INTRODUCTION

The pressure on water resources is increasing, mainly as a result of human activities such as land use change (advance of the agricultural frontier), urbanization, population growth, increased demand for water, the consequences of which are aggravated by climate change and variations in natural conditions, the deterioration of natural resources and poverty make the country increasingly vulnerable to natural disasters, contamination of its water sources and the consequences that derive from it . [1]

Pollution of water resources, mainly resulting from population growth, industrial development and the indiscriminate use of pesticides, has contributed drastically to the degradation of water bodies, which compromises the quality of life of various organisms, including humans. Impacting factors such as the excessive use of water resources, deforestation in protected areas and the introduction of toxic substances in aquatic ecosystems have been arousing the interest of monitoring to assess and maintain the quality of surface water, considering that these actions are of fundamental importance for public health and community development [2].

Water quality can be characterized by several parameters, including physical, chemical and biological ones. One of the problems of this characterization, for surface waters, is its variation according to environmental variables, among which precipitation is one of the main ones, since it influences its quantity. P. B. Singh and V. Singh (2008) [3] reported that studies aimed at seeking fluctuation patterns of limnological parameters in lotic aquatic ecosystems have been approached with different focuses, such as: nictimeral, longitudinal, spatial and temporal, however, aspects related to patterns of seasonal variation of physical and chemical parameters of rivers and streams are rarely studied. These investigations are important, especially if carried out in different regions, in order to understand such environments and allow comparisons of patterns in the seasonal fluctuation of specific variables in different regional gradients.

According to Baig, et al. (2009), another relevant factor in monitoring is the identification of point and diffuse sources of pollution, since this information is fundamental to environmental management actions and the adoption of public policies aimed at maintaining the quality of the water body.

The Krishna River has its origin near the west coast of India and its delta is located in the State of Andhra Pradesh at the east coast. The watershed comprises an area of 250,000 km2, being equivalent to approximately 8% of the surface area of India as a whole. In Andhra Pradesh, rice is a major crop that uses excessive amounts of water kg^{-1} of rice produced. The reliance on rainfall is high, but the low and erratic nature of the monsoons in this tropical semi-arid zone leads to moisture deficit for crop production. The farmers receive irrigation water, but they have little control over its availability. The performance of large irrigation systems may be evaluated using several criteria, including agricultural productivity, reliability of water supply, and equity of water distribution over the command area Carpenter, et al (1998). Gaur et al. (2008) [6] adopted an integrated approach to assess how cropping patterns and the spatial equity of canal flow changed with water supply shocks in the left canal command area of Nagarjuna Sagar. The cropping pattern in a region depends on environment, soil type, rainfall, irrigation facilities, nearness to markets and profitability. Besides these, the socioeconomic conditions of farmers in the region will also decide the farming system. Among these, the rainfall and irrigation plays major role that influence the crops, cropping system, and farming systems.

The Krishna river is a clear example of the protected natural environment without industries, for which the low probability of large-scale contamination would be believed and where the population is concentrated in small nuclei, (Biggs, 2007) due to the above, it was established as a propitious point to carry out this study that seeks to determine the variation in the water quality of the river that supplies water for consumption to the population; through quality indices methodology that allows grouping physical-chemical and bacteriological parameters (Oxygen saturation percentage, fecal coliforms, pH, biochemical oxygen demand, nitrates, phosphates, temperature, turbidity, and total solids) to determine the quality of the vital liquid according to the different uses for which it is required.

The Krishna River has its origin near the west coast of India and its delta is located in the State of Andhra Pradesh at the east coast. The watershed comprises an area of 250,000 km^2, being equivalent to approximately 8% of the surface area of India as a whole. In Andhra Pradesh, rice is a major crop that

uses excessive amounts of water kg-1 of rice produced. The reliance on rainfall is high, but the low and erratic nature of the monsoons in these tropical semi-arid zones leads to moisture deficit for crop production. The farmers receive irrigation water, but they have little control over its availability. The performance of large irrigation systems may be evaluated using several criteria, including agricultural productivity, reliability of water supply, and equity of water distribution over the command area (Bhutta and Van der Velde 1992; Bos 1997; Gorant War and Smout 2005). Gaur et al. (2008) adopted an integrated

approach to assess how cropping patterns and the spatial equity of canal flow changed with water supply shocks in the left canal command area of Nagarjuna Sagar. The cropping pattern in a region depends on environment, soil type, rainfall, irrigation facilities, nearness to markets and profitability. Besides these,

the socioeconomic conditions of farmers in the region will also decide the farming system. Among these, the rainfall and irrigation plays major role that influence the crops, cropping system, and farming systems.

In this article, the spatial-temporal changes of the contamination of the Krishna River were analysed, through the variation of the physical, chemical and biological properties. Determining the water quality indices in the rainy season (due to increased precipitation and dragging of sediments).

DESCRIPTION OF THE KRISHNA RIVER BASIN:

The Krishna River is a river in the Deccan plateau and is the third-longest river in India, after the Ganges and Godavari. It is also the fourth-largest in terms of water inflows and river basin area in India, after the Ganges, Indus and Godavari. The Krishna Basin extends over an area of 258,948 km^2 (99,980 sq mi) which is nearly 8% of the total geographical area of the country. This large basin lies in the states of Karnataka (113,271 km^2), Telangana, Andhra Pradesh (76,252 km^2) and Maharashtra (69,425 km^2).It is the fifth largest basin in India. [8]

Sampling sites and parameter analysis

To carry out the analyses, four points for collecting water samples on the Krishna river and Chintapalli,, Pondugula, Chandarlapadu, and Tallaya Palem, (Table 1) were selected. The descriptions of the points are arranged as follows: 1 - point referring to the source of the river, located in Chintapalli is a village in the Atchampet mandal of the Guntur district; 2 - Stop near the bridge located nearby Pondugula, Mylavaram mandal, Krishna Districts (agricultural activity); 3 - Rural area of Chandarlapadu mandal of Krishna district in Andhra Pradesh (poultry, swine and agricultural activities); 4 - Tallaya Palem, Amaravati Mandal, Andhra Pradesh (agricultural activity);

Water samples were taken every two months in six different campaigns from August/2013 to June/2014, obeying the seasonality criteria (dry and rainy periods). The methodology used to determine the physical-chemical and microbiological parameters followed the rules of the American Public Health Association (APHA, 2005) [9]. In situ, the following were determined: transparency, with a Sech disc; pH, using a portable Quimis pH meter, model Q-400 HM; conductivity, Dissolved Oxygen (DO), salinity and temperature measurements, using a YSI multiparameter device, model 85/100 FT. For the other parameters: biochemical oxygen demand (BOD), chemical oxygen demand (COD), total phosphorus, total nitrogen, total solids, turbidity and thermotolerant coliforms, the samples were collected in the subsurface of the river, placed in appropriate bottles and kept in styrofoam boxes, with ice, at 4°C. Analyses were performed in triplicate. The calculation of the WQI was performed using nine predefined parameters, with a relative weight being assigned to each of them:

For inferential statistical analysis, the t test was used to compare the various parameters between dry and rainy periods. In order to simultaneously consider all the information obtained by the various parameters measured, a logistic regression was performed to discuss the relationship between these parameters and seasonality, classified in this study as dry and rainy seasons. The software used was SPSS®15.0 and the significance level adopted was 5%.

When necessary, data transformation was used to normalize them or to homogenize variances in order to satisfy the test assumptions, but for presentation, the data are expressed in their original format.

Table 1. Location of sampling points

S.No	Sampling Location	Latitude	Longitude
1	Chintapalli, (a village in the Atchampet mandal of the Guntur district)	16.689192	80.142083
2	Pondugula (Mylavaram mandal, Krishna Districts)	6.586385	80.259035
3	Chandarlapadu (Krishna district in Andhra Pradesh)	16.664891	80.143654
4	Tallaya Palem (Amaravati Mandal, Andhra Pradesh)	16.5388	80.538899

METHODOLOGY:

1. Biophysical and socioeconomic characterization of the basin was carried out by means of existing secondary information of the area related to the basin.
2. Delimitation of the Krishna river basin was carried out on the Vijayawada cartographic sheet, it was digitized and its morphometry was determined.
3. Characterization of the Krishna river and monitoring of surface water quality and determination of quality indices; Three sampling points were established within the Krishna river basin. Samples were taken to estimate the necessary parameters for the determination of water quality: Physicochemical and bacteriological parameters. The parameters that were measured were: (in situ) temperature, dissolved oxygen, conductivity and pH. They were analysed in the laboratory (nitrites, nitrates, phosphates, coliforms). Samples were taken in the months of the rainy season (April, May, June, August, October), and a fourth point in the water catchment area within the river was included in the sampling points, the analysis of these parameters they were carried out in the unified laboratory of sanitary chemistry and microbiology of the Nagarjuna University.
4. Estimation of the quality index, WQINSF, values were assigned according to the weighting factor of each of the variables on which it is based, in such a way that this index can be determined as [10]:

$$WQI = \sum_{i=1}^{9} W_i \times Q_i$$

Where:

Wi: denotes the importance or weighting factor of the variable (i) with respect to the other variables that make up the index. And weighted between 0 and 1, in such a way that the sum is equal to one. Qi: the quality of the parameter (i), based on its concentration and whose rating ranges from 0 to 100. (15)

HYDROMETRY

Table 3. Krishna River flows November 2013 to October 2014

Month/Year	**Plain Flow Length m^3/s**	**Average Flows m^3/s**
Nov-13	0.11	0.12
Dec-13	0.09	0.01
Jan-14	0.22	0.26
Feb-14	0.05	0.001
Mar-14	0.07	0.01
Apr-14	0.07	0.02

May-14	0.29	0.68
Jun-14	0.09	0.13
Jul-14	0.19	0.17
Aug-14	0.52	1.96
Sep-14	0.4	1.43
Oct-14	0.2	0.75

Table 4. Physical, chemical and bacteriological characteristics of point 1 (Chintapalli)

Parameter/month*	Apr-14	May-14	Jun-14	Aug-14	Oct-14
ºC temperature	20.25	19.2	19.8	19.4	18.3
Turbidity NTU	1.01	8.58	1.21	9.05	0.28
% Saturation of oxygen	68	72	76	68	64
BOD(mg/L)	18	29.7	26.3	21	27
Nitrates (mg/L)	2.3	3.5	1.1	1.9	6.1
Phosphates (mg/L)	0.2	0.4	0.32	0.39	0.43
Total Solids (mg/L)	132.3	77	109.6	123	145.2
pH	7.9	11.5	10.4	10.2	9
Fecal coliforms MNP/100ml	350	210	40	98.5	410.6

Table 5. Physical, chemical and bacteriological characteristics of point 2 (Pondugula)

Parameter/month*	Apr-14	May-14	Jun-14	Aug-14	Oct-14
ºC temperature	22.65	21.5	21.6	20.8	19.9
Turbidity NTU	0.9	37.6	1.34	28.8	1.37
% Saturation of oxygen	6	7.4	7.3	7	6.8
BOD(mg/L)	7.7	16	3.3	8.3	32.7
Nitrates (mg/L)	3	4.55	1.54	1.9	2.3
Phosphates (mg/L)	0.7	1.65	1.7	1.78	0.83
Total Solids (mg/L)	168.6	105.5	144.3	118.67	1985.4
pH	8.5	10.1	10	10.7	9.2
Fecal coliforms MNP/100ml	≥2400	≥2400	1100	461.1	344.8

Table 6. Physical, chemical and bacteriological characteristics of point 3 (Chandarlapadu)

Parameter/month*	Apr-14	May-14	Jun-14	Aug-14	Oct-14
ºC temperature	23.55	23.2	22.8	21.5	21.2
Turbidity NTU	1.22	28.4	1.16	38.9	1.65
% Saturation of oxygen	75	79	81	69	77
BOD(mg/L)	22	10.3	41.7	25.7	21.3
Nitrates (mg/L)	2.9	2.3	1.98	2	3.3
Phosphates (mg/L)	0.1	2.9	3.35	8.4	2.13
Total Solids (mg/L)	264.34	95.5	225.68	94.03	1950.2
pH	8.3	10.4	10	9.9	9.3
Fecal coliforms MNP/100ml	350	≥2400	≥2400	185	365.4

Table 7. Physical, chemical and bacteriological characteristics of point 4 (Tallaya Palem)

Parameter/month*	Apr-14	May-14	Jun-14	Aug-14	Oct-14
ºC temperature	23	22.8	22	21	21.5
Turbidity NTU	2.41	52	0.74	50.2	0.64
% Saturation of oxygen	76	79	81	70	86
BOD(mg/L)	15	16	23.3	26	27.3
Nitrates (mg/L)	2.7	2.5	1.54	1.7	6.6
Phosphates (mg/L)	0.5	1	1.22	0.54	1.78
Total Solids (mg/L)	227	94	201	79.01	203.33
pH	8.2	10.7	10.1	10.3	9.2
Fecal coliforms MNP/100ml	240	240	460	137.4	275.5

Table 8. Quality Indices of the upper part of the Krishna River

Long Plain*	Apr-14	May-14	Jun-14	Aug-14	Oct-14
Total ACI	60.21	49.19	56.98	52.66	50.23
quality range	Medium	Poor	Medium	medium	Medium
Use in drinking water (15)	Necessary purification treatment.	Doubtful for consumption.	Necessary purification treatment.	Necessary purification treatment.	Necessary purification treatment.
Use in agriculture (15)	Usable in most crops.	Treatment required for most crops	Usable in most crops.	Usable in most crops.	Usable in most crops.

Table 9. Quality Index of the middle part of the Krishna River

Long Plain	Apr-14	May-14	Jun-14	Aug-14	Oct-14
Total ACI	53.51	41.21	53.4	45.13	53.1
quality range	Medium	Poor	Medium	medium	Medium
Use in drinking water (15)	Necessary purification treatment.	Doubtful for consumption.	Necessary purification treatment.	Doubtful for consumption.	Necessary purification treatment.
Use in agriculture (15)	Usable in most crops.	Treatment required for most crops	Usable in most crops.	Treatment required for most crops	Usable in most crops.

Table 10. Quality Index of the lower part of the Krishna river

Long Plain	Apr-14	May-14	Jun-14	Aug-14	Oct-14
Total ACI	**57.78**	**45.88**	**49.05**	**48.63**	**50.23**
quality range	Medium	Poor	Poor	Poor	Medium
Use in drinking water (15)	Necessary purification treatment.	Doubtful for consumption.	Doubtful for consumption.	Doubtful for consumption.	Necessary purification treatment.
Use in agriculture (15)	Usable in most crops	Treatment required for most crops	Treatment required for most crops	Treatment required for most crops	Usable in most crops

Table 11. Water Quality Index water catchment area in the Krishna river

catchment area	Apr-14	May-14	Jun-14	Aug-14	Oct-14
Total ICA	59.09	43.64	45.75	41.77	50
Rango de calidad	Medium	Poor	Poor	Poor	Medium
Uso en agua potable (15)	Necessary purification treatment.	Doubtful for consumption.	Doubtful for consumption.	Doubtful for consumption.	Necessary purification treatment.
Uso en agricultura (15)	Usable in most crops.	Treatment required for most crops	Treatment required for most crops	Treatment required for most crops	Usable in most crops

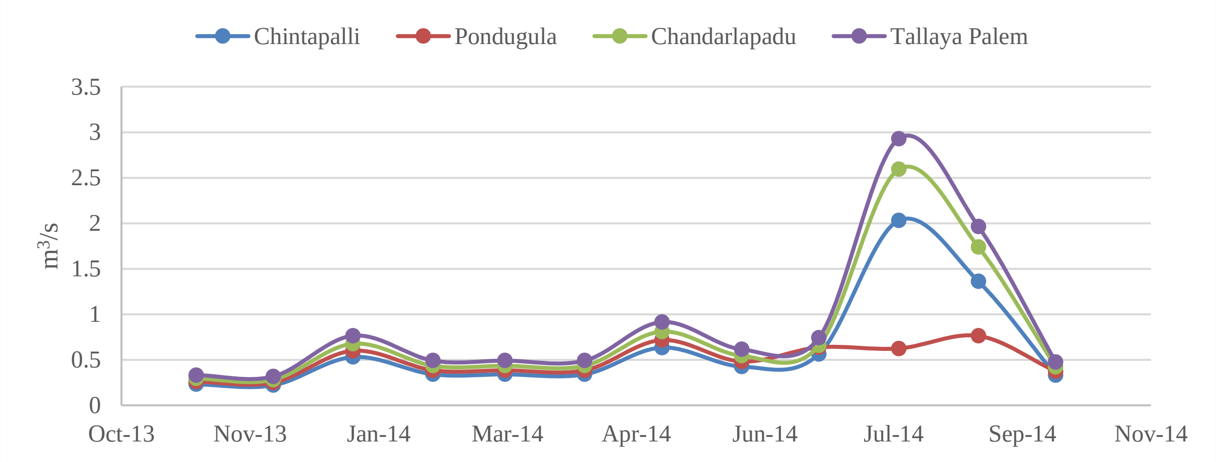

Figure 3. Flow comparison graph for different locations of the basin

Figure 3 shows the months in which the flow decreases considerably and it is from February to April; and the months that report the greatest amount of flow are from August to October, influenced by the rainy season. The months of May and January present a slight increase in the flow, the month of May affected by the tropical storm and the month of January could be due to rainfall in the upper part of the basin.

Water Quality Indices: In the Krishna River Basin through the association of indicators that were simplified by means of a numerical expression as observed in tables 7, 8, 9 and 10, in which it was determined that the index Water quality is within a medium to poor range (40.21 and 60.21), which determine that for human use it must be treated and for agricultural purposes it can be used for most crops. It is important to highlight that in the vicinity of the river there are several roads and accesses that are an important source of contamination as well as degradation of the resources associated with the river; in addition to the anthropogenic pressure that occurs in the resource due to the various uses for which it is used; for agriculture (mainly tomato cultivation) and human supply due to the fact that it supplies the municipal seat of Vijayawada to a large extent.

CONCLUSIONS:

1. The quality of the Krishna river in general terms is within the average classification which must receive certain treatments for its use; In addition to presenting variation in the physical, chemical and bacteriological quality in the upper, middle and lower part of the basin, determining that the most contaminated point is the one found in the Krishna district rural villages, lower part of the basin and the one with the best quality is the point located in the village of Chintapalli, the upper part of it.
2. The morphometry of the basin indicates that the shape is elongated. Which is related to

the amount of runoff that occurs in the area. With a low drainage density that reflects a poorly drained area with a very slow hydrological response. The average slope of the basin is 43.21% and the slope of the main channel is 5.724%.

3. The flow decreases considerably from February to the month of April (reported minimum flow is 0.001 m^3/s in the month of February in the lower part of the basin) and the months that report the greatest amount of flow are from August to October (flow maximum reported is 2.33 m3/s in the month of August at the midpoint of the basin in Pondugula), there being an increase in the flow in the month of May.
4. The quality of the Krishna river water resource according to the WHO drinking water standard defines that some parameters are outside the maximum permissible limit, which is why the use of Krishna river water must receive purification treatments before consumption.
5. The quality indices of the Krishna river water in the rainy season for human consumption are between the range of medium to poor quality (40.21 and 60.21) which could be used with purification treatments. And for agricultural use it could be used for most crops.

References

[1]. Singh, Vijay & Mishra, Ashok & Chowdhary, Hemant & Khedun, C Prakash. (2014). Climate Change and Its Impact on Water Resources. 10.1007/978-1-62703-595-8_11.

[2]. B. Goldar and N. Banerjee, "Impact of Informal Regulation of Pollution on Water Quality in Rivers in India," Journal of Environmental Management, Vol. 73, No. 2, November 2004, pp. 117-130.

[3]. P. B. Singh and V. Singh, "Pesticide Bioaccumulation and Plasma Sex Steroids in Fishes during Breeding Phase from North India," Environmental Toxicology and Pharmacology, Vol. 25, No. 3, May 2008, pp. 342-350.

[4]. Baig, J.A., Kazi, T. G., Arain,M. B., Afridi, H. I., Kandhro, G.A., Sarfraz, R. A., Jamali, M. K. and Shah, A. Q. (2009). Evaluation of arsenic and other physico-chemical parameters of surface and ground water of Jamshoro, Pakistan. Journal of Hazardous Materials. 166, 662–669.

[5]. Carpenter, S.R., Caraco, N.F., Correll, D.L., Howarth, R.W., Sharpley, A.N. and Smith, V.H. (1998). Non point pollution of surface waters with phosphorus and nitrogen. Ecological Applications. 8: 559-568.

[6]. Gaur, A & Biggs, Trent & Gumma, Murali & Teluguntla, Pardhasaradhi & Turral, Hugh. (2008). Water Scarcity Effects on Equitable Water Distribution and Land Use in a Major Irrigation Project—Case Study in India. Journal of Irrigation and Drainage Engineering. 134. 10.1061/(ASCE)0733-9437(2008)134:1(26).

[7]. Biggs, T. W., Gaur, A., Scott, C. A., Thenkabail, P., Rao, T. P. G., Murali, K. G., Acharya, S. K., and Turral, H. 2007. "Closing of the Krishna Basin: Irrigation development, streamflow depletion, and macroscale hydrology." IWMI Research Rep. 111, International Water Management Institute, Colombo, Sri Lanka.

[8]. Gumma, Murali & Thenkabail, Prasad & Nelson, Andy. (2011). Mapping irrigated areas using MODIS 250 meter time-series data: a study on Krishna River Basin (India). Water. 3. 19. 10.3390/w3010113.

[9]. APHA, AWA, WPCF. (2005). Standard methods for the examination of water and wastewater, 21st ed. American Public Health Association, American Water Works Association, Water Environment Federation, Washington, DC

[10]. Kaurish, Fredrick & Younos, Tamim. (2007). Developing a Standardized Water Quality Index for Evaluating Surface Water Quality1. JAWRA Journal of the American Water Resources Association. 43. 533 - 545. 10.1111/j.1752-1688.2007.00042.x.