QUALITY ASSESMENT OF
SURFACE WATER OF KRISHNA RIVER

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ABSTRACT

The Krishna river and its tributaries drain a very large area in South India. The Krishna river water has significant socio-economic value to people living in the basin, e.g. the river water is used for drinking, industry, for recreation, hydropower, as a carrier of municipal and industrial wastes and in many cases water is drawn for agricultural uses as well. In this context, hydro chemical analyses were carried out on surface water of Krishna River at Wadenpalli for entire year. The analytical results indicate that calcium and bicarbonate are the dominant cations and anions respectively. DO levels were observed to be around 70-80% of saturation concentration. The concentrations of fluoride, nitrate and phosphate were considerably low when compared with that of groundwater in the region. However values of most of the parameters are observed with in the range of WHO specification. Quality assessment of Krishna river water shows that surface water is suitable for domestic use although check should be kept on anthropogenic and diffuse inputs. Based on SAR, RSC and percent Sodium the surface water falls in the category of excellent to good quality for irrigation. Ca-Mg-HCO_3 is the dominant hydro chemical facies.

Key Words: Krishna River, Water Quality Assessment, Hydro chemical analysis, SAR, RSC,

INTRODUCTION

Rivers play an important role in human development and are an important natural resource. The hydro-chemical characteristics of water determine its usefulness for municipal, commercial, industrial, agricultural and domestic waster supplies. Development provides opportunities for pollution of river water. With urbanization, industrialization and rapid growth in world population man has manipulated the natural hydrological cycle both quantitatively and qualitatively. The study of water quality involves a description of occurrence of various constituents in water and relation of these constituents to water use. The present study was undertaken to carry out quality assessment of surface water of Krishna River at Wadenpalli and to ascertain its suitability for domestic and agricultural purpose. The growing awareness that chemical constituents are an integral part of hydrologic system has lead to greater emphasis on determining relationships between dissolved pollutants (both cations and anions) and other hydrologic parameters. One particular aspect of popular interest is to study the quality aspects of river water to decide on the class of water and its use for different purposes.

DESCRIPTION OF THE STUDY AREA

Krishna River is one of the major perennial rivers, which drains three important States of South India. This is the second largest river basin of South India which is situated between longitudes $73^0\ 21^1$ E and $81^0\ 09^1$ E and latitudes $13^0\ 07^1$ N and $19^0\ 25^1$ N in the Deccan plateau covering large areas in the States of Maharastra, Karnataka and Andhra Pradesh. The location of the basin is shown in Fig. 1. The river Krishna drains an area of 258,948 km^2, which is nearly 8% of the total geo-graphical area of the country. The total population in the basin as per 1991 census has been estimated as 60.78 million. There are about 25 towns within the basin with the population more than hundred thousands. The river and its tributaries flow through different terrain having varied land use activities, soil conditions, vegetation and agricultural practices. The water potential of the River Krishna and its tributaries are mainly used for drinking, industries, irrigation and power generation. The study concentrates on the water quality obtained from the monitoring station at Wadenapalli. In addition to other districts, major parts of Nalgonda and Guntur districts drain into this part of the Krishna river in Andhra Pradesh. Typical tropical climate prevails in the basin for better part of the year. For practical considerations two seasons: dry (December – May) and wet (June – November) seasons exist in the area. The basin is characterized by predominantly gentle slopes and moderately to poorly drained soils (Sekhar, 2001). Typically the basin consists of sandy loam, clay loam, fine loam, rocky soils, mixed (calcareous) and clayey soils (black cotton soils).

METHODOLOGY

The Central Water Commission (CWC) of Government of India is collecting hydrological data i.e., gauge and discharge observations and water quality data in River Krishna. Standard methods for examination of water and wastewater (APHA, 1992) are being adopted at all the 57 sites for collecting the discharge and water quality data. Samples were collected thrice a month over the entire year. They were collected in the middle of the stream to avoid the effect of secondary flux at the shoreline. Water is collected at a depth of 10-15cm to have completely mixed sample. Data and preliminary information are obtained from Central Water Commission, National Remote Sensing Agency (NRSA), Andhra Pradesh State Remote Sensing Application Center (APSRAC), National Hydrological Project, etc.. Water quality data namely, EC, pH, K^+, Na^+ , Ca^{++}, Mg^{++} , $HCO^-{}_3$, Cl^- , F^- , $SO^{--}{}_4$, $NO^-{}_3$, etc., is used for quality assessment study.

RESULTS AND DISSCUSSION

The average monthly chemical composition of surface water of Krishna River at Wadenapalli is presented in Table 1. The analytical result shows that river water is alkaline in nature as the pH range is 7.35 to 8.67. Specific conductance which is measurement of ionic strength of water varies between 225 -555micromhos/cm. Water is moderately hard with range of 116-148mg/L. Bicarbonate is most dominant anion followed by chloride and then sulphate. Due to proximity of study area to ocean, it is likely that sizable part of chloride is of atmospheric origin or contribution from point sources. Generally it’s the cation associated with the chloride which produces harmful effect. Chloride-discharge relationships can help in identification of sources. In terms of general water qaulity, the water at the monitoring station on River Krishna contained lot of suspended solids immediately after the rainfall events and especially during the wet season. In the wet season, the runoff conveys both suspended and dissolved materials into the river. During the dry spells, though flows are less, the water is clear with no considerable suspended sediment. Due to lack of data regarding suspended solids, this particular comparison is based on physical observations only

Table 1 Average Monthly Chemical Composition of River Water

Parameter	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
pH	**8.67**	**8.43**	**8.36**	**8.05**	**8.40**	**8.20**	**8.19**	**7.64**	**8.14**	**8.18**	**7.35**	**8.42**
Sp.cond	**232**	**309**	**468**	**437**	**441**	**555**	**519**	**250**	**225**	**258**	**323**	**246**
K^{+}	**1.17**	**1.56**	**1.56**	**1.56**	**1.955**	**2.34**	**2.34**	**1.17**	**1.17**	**1.17**	**1.17**	**1.17**
Na^{+}	**14.71**	**23.67**	**34.02**	**34.02**	**29.42**	**38.16**	**9.19**	**12.64**	**9.42**	**12.41**	**18.85**	**15.4**
Ca^{++}	**32.06**	**42.08**	**41.28**	**27.05**	**33.06**	**35.07**	**40.08**	**26.05**	**37.07**	**30.06**	**35.07**	**37.04**
Mg^{++}	**8.99**	**8.99**	**7.05**	**17.99**	**10.94**	**14.95**	**9.95**	**20.05**	**13.01**	**17.99**	**13.98**	**8.02**
HCO_3^{-}	**55.26**	**76.17**	**97.83**	**147.9**	**150.9**	**122.5**	**147.1**	**187.5**	**93.35**	**97.83**	**124.7**	**101.6**
Cl^{-}	**22.33**	**33.32**	**36.86**	**35.57**	**50.69**	**55.29**	**60.26**	**28.71**	**21.97**	**29.77**	**25.87**	**29.42**
F^{-}	**0.246**	**0.493**	**0.17**	**0.436**	**0.455**	**0.551**	**0.627**	**0.246**	**0.246**	**0.323**	**0.436**	**0.398**
SO_4^{--}	**14.89**	**34.1**	**34.58**	**29.78**	**33.14**	**70.12**	**77.32**	**22.09**	**11.04**	**15.85**	**12.01**	**13.93**
NO_3^{-}	**0.867**	**1.3**	**2.16**	**1.673**	**1.79**	**1.23**	**1.3**	**3.96**	**1.79**	**1.85**	**1.3**	**4.2**
PO_4^{---}	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.03**	**0**	**0**	**0.09**	**0**
Hardness	**116**	**141**	**131**	**141**	**130**	**148**	**143**	**148**	**145**	**126**	**144**	**124**
Na %	**21.26**	**26.34**	**35.55**	**34.02**	**32.99**	**35.32**	**12.2**	**15.59**	**12.2**	**15.21**	**21.87**	**20.87**
S.A.R	**0.59**	**0.86**	**1.29**	**1.24**	**1.13**	**1.36**	**0.34**	**0.45**	**0.34**	**0.44**	**0.68**	**0.6**
R.S.C.	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

All ionic concentrations are in **mg/L**
Sp.conductance or EC in **micromhos/cm**
SAR= SODIUM ADSORPTION RATIO
RSC= RESIDUAL SODIUM CARBONATE in meq/L

and hence assessment of source contributions using appropriate models (Sekhar and Indira 2002). However, during few months chloride concentration exceeds the sodium concentration indicating the base-exchange phenomenon. Table 1 shows low concentration of fluoride for most of the time in the year. The drinking water should have 0.6-1.5mg/L of fluoride. Results indicate low concentration of Nitrates and Phosphates. Low solubility of phosphate bearing minerals restricts its concentration in natural aquatic system. Under natural conditions the concentration of phosphate should not exceed 0.05mg/L. but in the month of November it suddenly jumped to 0.09mg/L which is indicative of anthropogenic inputs. Nitrate is important consideration with regard to potable waters. It has been reported that Nitrate concentration above 20mg/L may cause methemoglobinemia in infants, a disease characterized by blood changes. Regarding industrial water supplies nitrates are reported to be injurious to dyeing of wool and silk fabrics. They are also harmful to fermentation process and cause disagreeable tastes to bear. The average concentrations over the year of various ions is indicated in Fig.2.

Calcium and Magnesium are the dominant cations in river water. Concentration of Ca and Na ranges between 26.05-42.08mg/L and 7.05-20.05mg/L respectively. Calcium is an essential element and human body requires approximately 0.7-2.0g of calcium per day as food element, the amount which can not be supplied even by hard water. Infact calcium deficiency is the most common nutritional lack in many parts of world. Magnesium is relatively non toxic to man. Magnesium salts act as cathartics and diuretics(Manivasakam 1996) among animals as well as human beings. Magnesium is essential to normal plant growth. Calcium and magnesium ions in irrigation water tend to keep soil permeable and in good tilth. Potassium is the least dominant cation and its concentration ranges between 1.17-1.955mg/L. Potassium is an essential nutritional element, but in excess amounts it acts as cathartic (laxative). Though low concentration of potassium in irrigation water is essential for plant nutrition, it must be maintained in proper balance with other mineral nutrients for good plant development.

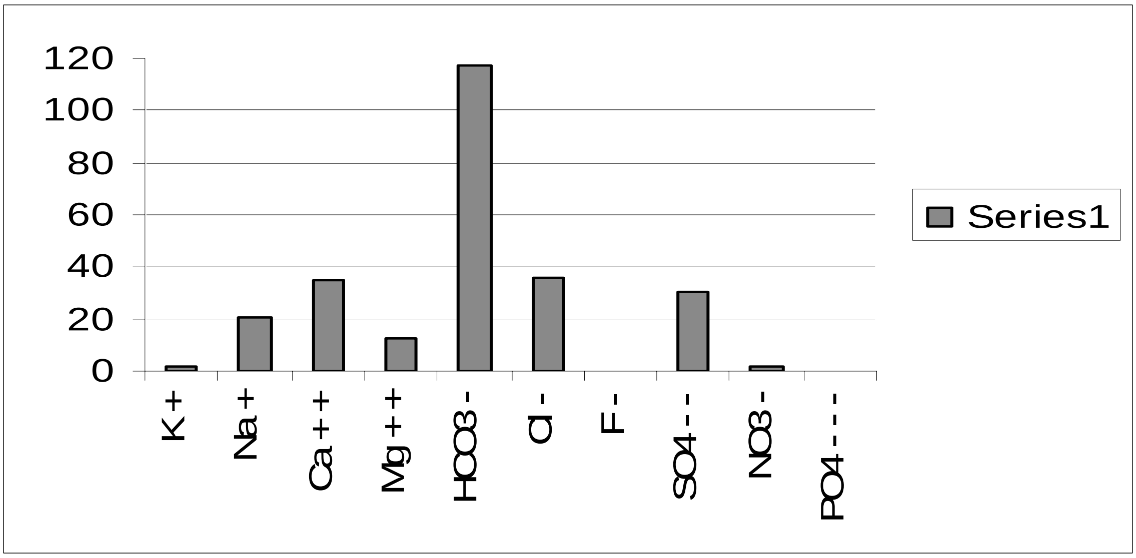

Fig. 2. Average concentrations over an year

The data obtained by chemical analysis were evaluated in terms of its suitability for drinking and irrigation purpose. Table 2 shows the range of ionic concentration in the river water of study area and the prescribed specification of WHO standard for drinking water.

Boron is also reported in study area with a range of 0.00-0.95mg/L. Boron in drinking water is not generally regarded as a hazard, however higher concentration can affect central nervous system. National surveillance agency has set a guide line value of 0.3mg/L of boron for drinking water. Though boron is an essential in the nutrition of higher plants, concentration exceeding 0.5mg/L may be deleterious for certain crops. Dissolved oxygen is observed with in the range of 6.75-8.50mg/L. However DO fluctuations over time and space in the river water can be attempted with more details at different sections with different time intervals. The overall DO levels in the river are observed to be not less than 70-80% of saturation DO. Analytical data shows that value of most of the parameters lies with in the specifications of WHO but with few exceptions as fluoride(low).

Table 2. Ranges of Chemical Parameters of Krishna River and WHO Standards

Parameter	WHO(1984)	Range in study area
EC(microS/cm)	1400	225-555
PH	6.5-8.5	7.35-8.67
K^{+}		1.17-1.955
Na^{+}	200	9.19-34.02
Ca^{++}	500	26.05-42.08
Mg^{++}		7.05-20.05
HCO_3^{-}		55.26-150.9
Cl^{-}	250	21.97-60.26
F^{-}		0.17-0.627
SO_4^{--}	400	11.04-77.32
NO_3^{-}		0.867-4.2

(All ionic concentrations are in mg/L)

Parameters such as Sodium adsorption ratio (SAR), percent Sodium and Residual sodium carbonate are estimated to asses the suitability of river water for irrigation. EC and Sodium concentration is very important in classifying irrigation water. While a high salt (high EC) leads to formation of saline soil and a high Sodium concentration leads to development of an alkaline soil. The Sodium or alkali hazard in the use of water for irrigation is determined by the absolute and relative concentration of cations and is expressed in terms of sodium adsorption ratio (SAR) and it be calculated from by the formula:

$$SAR= Na/[(Ca+Mg)/2]^{0.5}$$

There is a significant relationship between SAR values of irrigation water and the extent to which sodium is adsorbed by the soil. If the water used for irrigation is high in Sodium and low in Calcium, the cation-exchange complex may become saturated with Sodium. This can destroy the soil structure owing to dispersion of clay particles .The calculated value of SAR in the study area ranges between 0.34-1.36. Data is plotted on the US salinity diagram, in which EC is taken as salinity hazard and SAR is taken as alkalinity hazard. Fig. 3 indicates that in the months of September, December, January water falls in the category C1S1 and for rest of the year it falls in C2S1 category indicating excellent to good type of water for irrigation without any hazard.

The Sodium percentage in the study area ranges between 12.2-35.55%. As per BIS standard maximum percentage sodium is 60% which is recommended for irrigation water. The Residual Sodium Carbonate (RSC) was reported to be 0.00. Water containing less then 1.25 meq/L are of RSC are probably safe, those containing 1.25 -2.5meq/L are marginal and those with more than 2.5meq/L are not suitable. Irrigation water having RSC value greater than 5meq/L have been considered harmful to growth of plants.

The evolution of water and relationship between rock types and water composition can be evaluated by trilinear Piper diagram. The piper diagram given in Fig. 4, is an ingenious construction which consist of two triangular diagrams at the lower left and lower right side, describing the relative composition of cations and anions and an intervening diamond shaped diagram that combines the composition of cations and anions. The plot of chemical data on trilinear diagram reveals that majority of water samples are of **Ca-Mg-HCO_3** type. The soil morphology of the basin also suggests such dominant ions in river water.

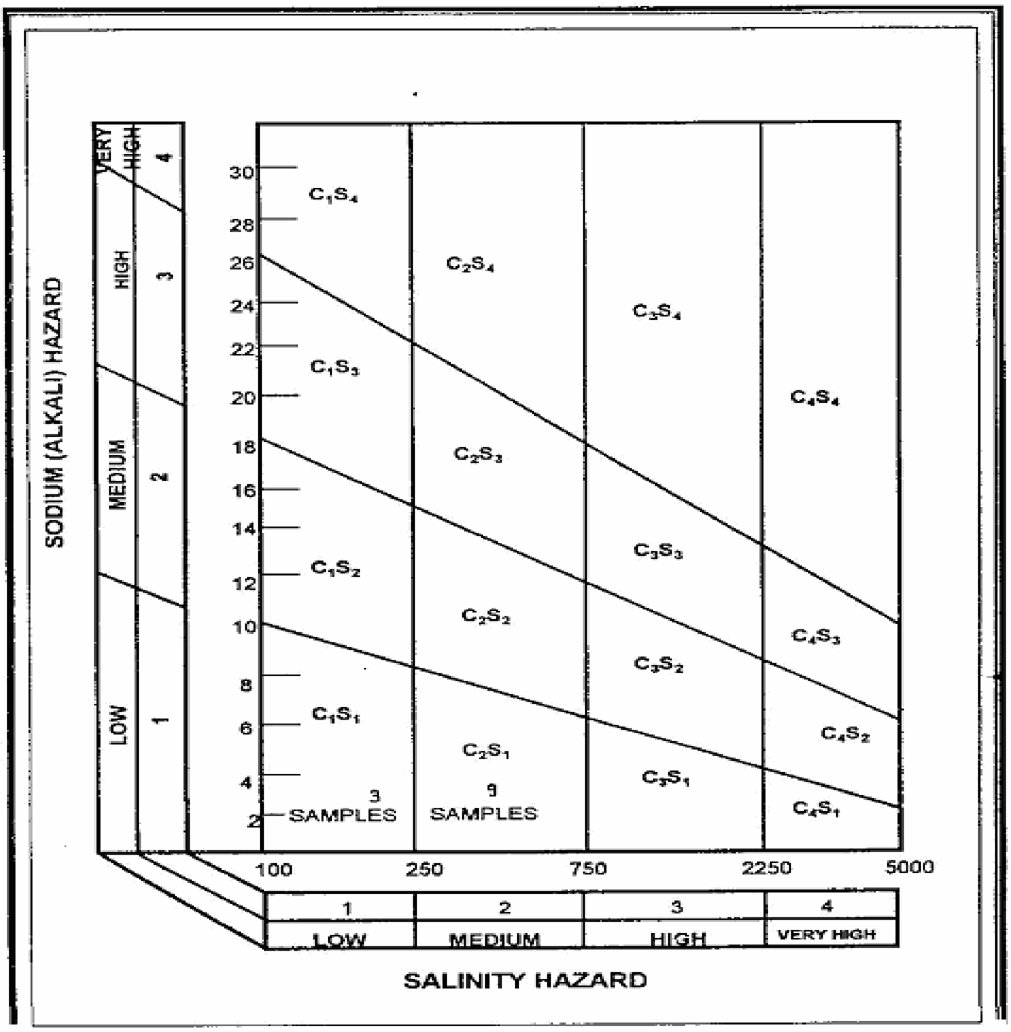

Fig. 3 US SALINITY DIAGRAM

CONCLUSIONS

The surface water chemistry Krishna reveals that the water is suitable for domestic use although it was observed with low level (less than 0.6mg/L) of fluoride which causes dental caries, but Indian food habits compensates for this deficiency. Also, most of the water supply schemes are combinations of groundwater (generally rich in fluorides) and surface waters, hence, fluoridation of water supplies is not quite popular. Moreover check should be kept for pollution from external sources. The quality assessment for agricultural use indicates that water is of excellent to good quality and can be used for irrigation.Ca-Mg-HCO_3 is the dominant hydro chemical facies.. As the concentrations of nutrients (in the form of phosphates and nitrates) are low (in spite of higher loads), no algal blooms are observed in the river yet, indicating the river to be under aligotrophic condition. However, it is time to think about effective methods for controlling point and non-point source inputs into the river.

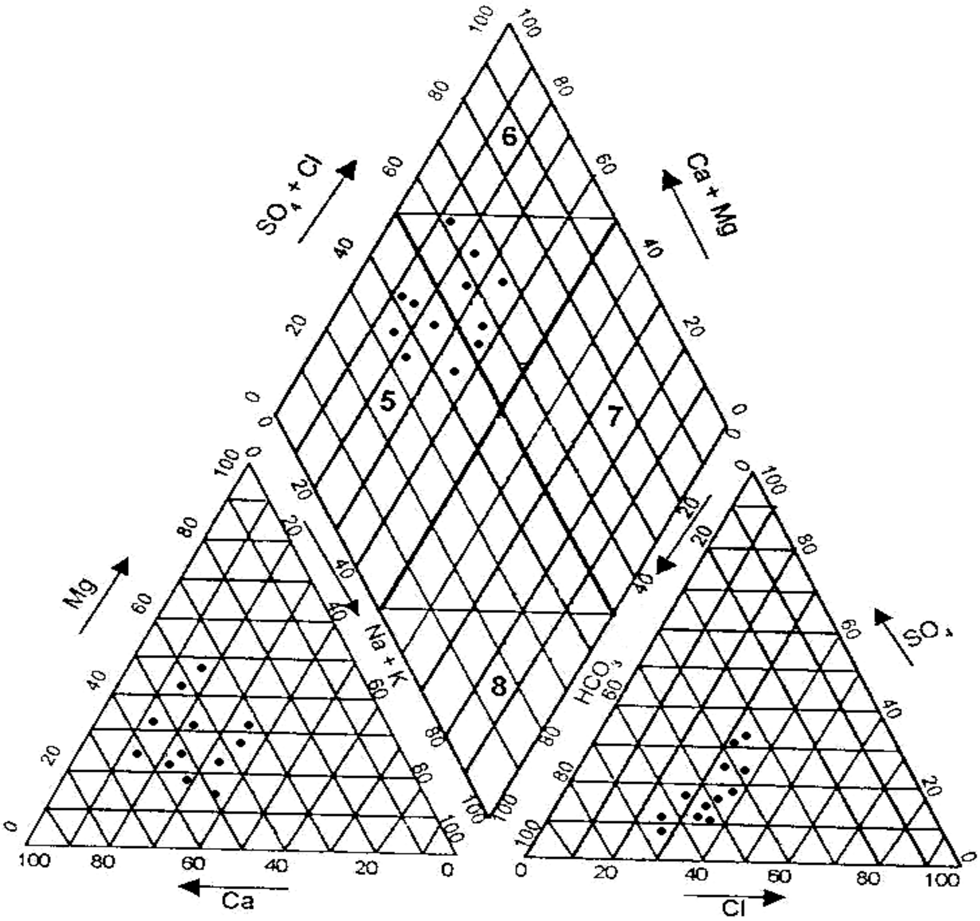

Fig. 4 Piper Trilinear Diagram

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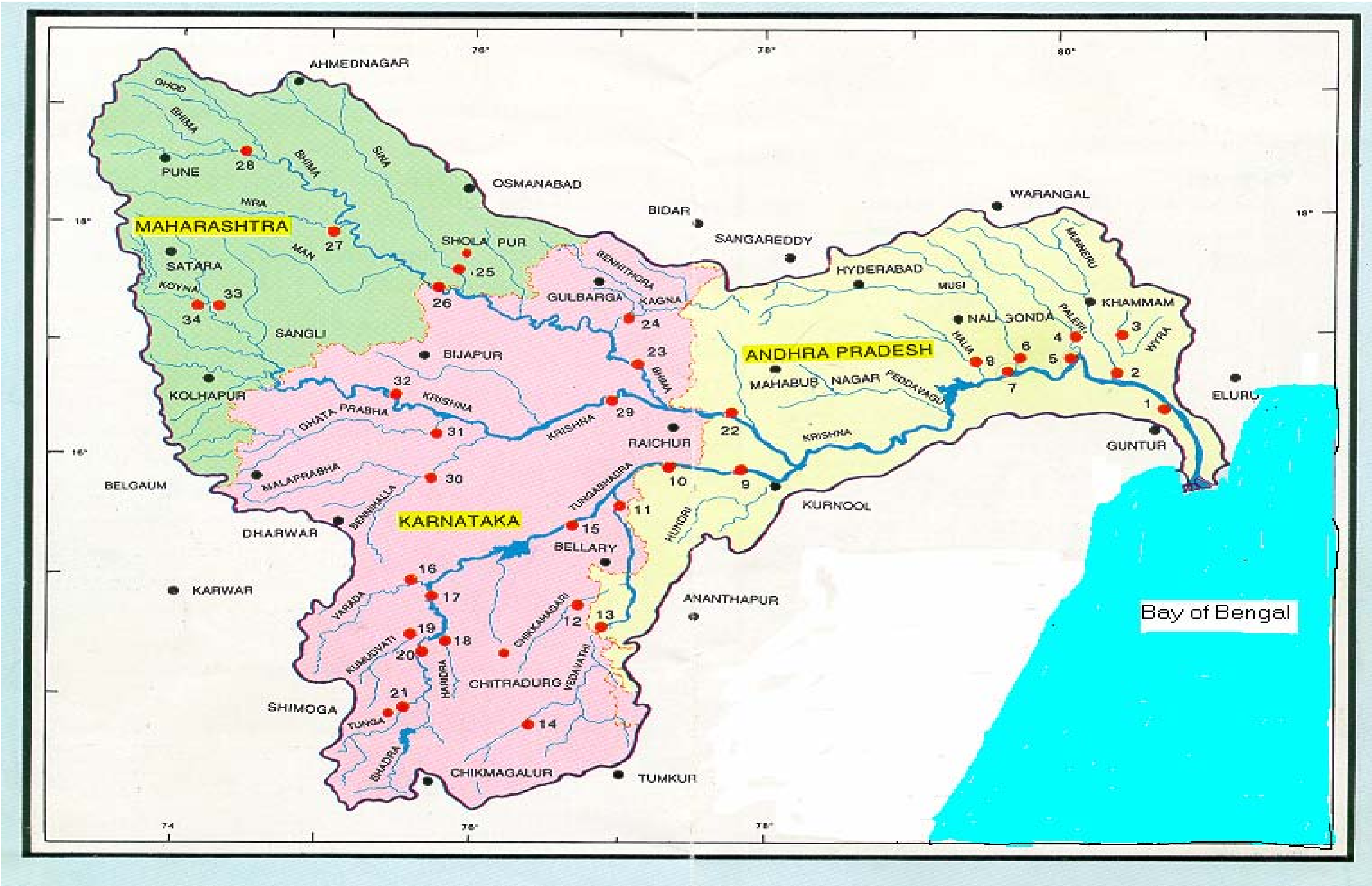

Station 5 Wadenapalli

Fig 1 Krishna River Basin