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IWRM Studies: Surface water and groundwater interaction in Y drain of Lower Errakalva basin

National Institute of Hydrology

Deltaic Regional Centre

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Preface

As societies develop, water resources within a given basin become increasingly diverted, controlled, and used. Water flowing out of sub-basins is often committed to other downstream uses, and reduced outflow to the sea has detrimental effects on flushing out sediments, reducing pollution in water, controlling salinity intrusion, sustaining estuarine and coastal ecosystems etc.,.

Errakalva River in Andhra Pradesh drains the eastern parts of West Godavari district for about 180 km and joins the Upputeru river, which takes off from the Kolleru lake and falls into Bay of Bengal. Errakalva enters the Godavari western delta, after draining an area of including that of upstream catchment of 2330.10 km2, near Nandamuru aqueduct in Tadepalligudem Mandal and emerges as 'Yenamadarru Drain' or Y Drain. It appears that while taking up irrigation projects most of the erstwhile rivers and streams are made part of command area and lost their originality to be treated as part of drainage system. Present study is part of ongoing IWRM project in the pilot basin of Errakalva River in Andhra Pradesh and is intended to investigate the interaction surface water and groundwater in the lower errakalva basin that forms Y-drain region.

This study on 'Surface water and groundwater interaction in Y drain of Lower Errakalva basin' is part of work programme of the Deltaic Regional Centre, Kakinada and carried out under the supervision of Dr. J. V. Tyagi, Scientist F and Coordinator by Dr. S. V. Vijaya Kumar, Scientist F as Principal Investigator. Dr. Y. R. S. Rao, Scientist F and Dr. J. V. Tyagi, Scientist G as other investigators with Shri T. Vijaya, P.R.A., Shri U. V. N. Rao, P.R.A and P. R. Rao, R.A., as support staff.

Abstract

To understand the interaction of surface water and groundwater it is important to know the mixing of various sources of water like precipitation or evaporated or storage water bodies and releases from them or recharge to aquifers to understand the man's influence on streams and aquifers. It can help plan or prevent deterioration of water quality by salinization and pollution. The environmental isotopic methods provide a valuable approach to understand the complex phenomena of rainfall - surface water - groundwater interactions. The application of the environmental isotope methods to understand the origin of sources of surface and groundwater with respect to its recharge is based on the spatial and temporal variability of the isotopic contents of water. Errakalva river drains West Godavari district for about 180 km and joins the Upputeru river, which takes off from the Kolleru lake falls into Bay of Bengal. Errakalva enters the Godavari western delta, after draining an area of including that of upstream catchment of 2330.10 km^2, near Nandamuru aqueduct of Tadepalligudem Mandal and emerges as Yenamadarru drain and debauches in to Bay of Bengal through Upputeru major creek. In this study, as part of IWRM project in Errakalva Pilot basin, variation of measurement of stable isotopes of Deuterium and Oxygen i.e, δD and δ^{18}O in the water samples of precipitation, canal water, stream water, tank water and groundwater collected in the Yanamadurru drain, discharging from 394.93 km^2 in deltaic plain is studied and analysed. The variation of stable isotope $^{18}O_{16}$ in the surface and ground waters of the lower part of Errakalva basin called Yanamadurru drain or Y Drain system is discussed to understand the proportion of mixing of sources waters in surface water and groundwater at different locations.

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1.0 INTRODUCTION

As societies develop, water resources within a given basin become increasingly diverted, controlled, and used. Water flowing out of sub-basins is often committed to other downstream uses, and reduced outflow to the sea has detrimental effects on flushing out sediments, reducing pollution in water, controlling salinity intrusion, sustaining estuarine and coastal ecosystems etc.,. The perception that water surplus from the most down-stream project is 'lost' and water that sustains flood river regime and part of ecosystem functioning and crucial for inland fisheries as not a genuine 'use' has dried up all our rivers and even a moderate rainfall creates disastrous flooding of lands along their reaches. Thus, it calls up for systematic advanced investigations to understand the effects of developments and to plan appropriate interventions.

The impact of water resources developments can be there on the severity, duration and occurrence of floods in the middle and lower reaches of any river basin. Water resources projects are meant to store water or divert water mainly for irrigation of crops. Human activity has become a significant changer in hydrologic budget at basin scale. Interference made in one part of the basin are felt at distant places unexpectedly. Hence study of such water resources development projects at basin scale on the occurrence of river flows and floods helps in proper basin planning. The impact of changes in flow regime can be felt on the aquatic life of the river too. Water is not only essential for mankind but also for all living organisms. The timing, quantity and quality of river water has direct impact on the biological systems the river basin, especially along the river corridor. Changes in flow regime impact the survival of the habitat and may damage the connectivity of freshwater ecosystem.

Water originates from precipitation as rainfall runoff, river flow or groundwater recharge. This means that the amount of water available in a system is related to its storage capacity and determines the maximum available resources for exploitation. By undertaking water balance approach of an aquifer system groundwater recharge can be estimated. Nevertheless, in many cases recharge and water flow are rather complex and more information of the actual process is desirable. Knowledge of the recharge process is also important for preventing deterioration of water quality by salinization and pollution. In regions where temperature and precipitation are distinctly seasonal and groundwater flow occurs in crystalline or Karstic rocks, the stable isotope content of groundwater may indicate the seasonal dependency of recharge. In addition, stable isotope content can also be used to determine the ratio of seasonal recharge or precipitation in a given area.

Isotopes are elements that contain atoms with required number of protons but different numbers of neutrons. The concept that the hydrological cycle system can be viewed as a global distillation column of waters fed by evaporation from the ocean as moisture which condenses as a result of cooling of air masses as it rises to higher levels. The degree of depletion of heavy isotopic water species of hydrogen and oxygen is correlated in the residual waters, provided there exists equilibrium between the condensed phases and the vapors at all times. But, according to Fritz and Fontes (1980), evidently evaporation from the ocean does not produce vapor in isotopic equilibrium with it. For stable isotopes, their differences in isotopic species in water play an important role in the variation that is observed in the atmospheric water cycle by promoting fractionation effects during vapor/liquid and vapor/solid phase changes. Thus, isotope fractionation occurs at each phase change except at sublimation and at melting of compact ice.

The environmental isotopic methods provide a valuable approach to understand these complex phenomena as well as to test the validity of the alternative hypothesis. The application of the environmental isotope methods to understand the origin of groundwater with respect to its recharge is based on the spatial and temporal variability of the isotopic contents of water. The stable isotopes oxygen-18 ($^{18}O_{16}$) and deuterium (D or $^{2}H_{1}$) in precipitation have long been known as potential tracers for natural waters yet they have been little exploited for measuring percolation. The flux of HDO and $H_2{}^{18}O$ from an open water body to the atmosphere is reduced relative to the flux of the lighter $H_2{}^{16}O$ because of the lower vapour pressure of the former species, which causes fractionation in evaporation and condensation processes.

The advantage of the environmental isotopes as hydrologic tracers is that nature and anthropogenic activities show the path for the tracer experiment. Some of the tracers are the water molecules themselves containing stable or radioactive isotopes characteristic of conditions of recharge, or time or precipitation. The solute category of environmental tracers requires careful consideration of possible sources of isotope itself in the aquifer or sources of stable isotopes of the same element. The aquifer derived stable isotope is important as well, as the reported laboratory measurement is in terms of the ratio of the isotope with respect to the amount of total element. Kumar et. al (2010) discussed about variation of stable isotopic characteristics of Indian precipitation by analyzing precipitation samples collected from many locations across India. Vijaya Kumar et. al (2009) presented on the stable isotope characterization of groundwater in a sandstone aquifer in Andhra Pradesh. Vijaya Kumar et. al, (2011) carried out stable isotope characterization of groundwater in pushkar canal command area.

Errakalva River in Andhra Pradesh drains the eastern parts of West Godavari district for about 180 km and joins the Upputeru river, which takes off from the Kolleru lake and falls into Bay of Bengal. Errakalva enters the Godavari western delta, after draining an area of including that of upstream catchment of 2330.10 km2, near Nandamuru aqueduct in Tadepalligudem Mandal and emerges as ‘Yenamadarru Drain’ or Y Drain. It appears that while taking up irrigation projects most of the erstwhile rivers and streams are made part of command area and lost their originality to be treated as part of drainage system. Present study is part of ongoing IWRM project in the pilot basin of Errakalva River in Andhra Pradesh and is intended to investigate the interaction surface water and groundwater in the lower errakalva basin that forms Y-drain region.

2.0 STUDY AREA

The Eerrakalva river rises in the eastern slopes of the eastern ghats at the southwest side of the Papikonda hill ranges on the boarder of West Godavari and Khammam districts. It enters into West Godavari district after 6.4 km run in Khammam district and runs in West Godavari district for about 180 km and joins the Upputeru river, which takes off from the Kolleru lake falls into Bay of Bengal. Errakalva enters the Godavari western delta near Nandamuru aqueduct of Tadepalligudem Mandal and emerges as Yenamadarru drain and debauches in to Bay of Bengal through Upputeru major creek. It is within the longitudes 80^0 45' 00" E and 81^0 50' 00" E and latitudes 16^0 15' 00" N and 17^0 30' 00" N. The river with a total catchment area of 2725.03 km^2 out of which 2330.10 km^2 is in upland and 394.93 km^2 in deltaic plain. The location of the study area is shown in Figure 1.

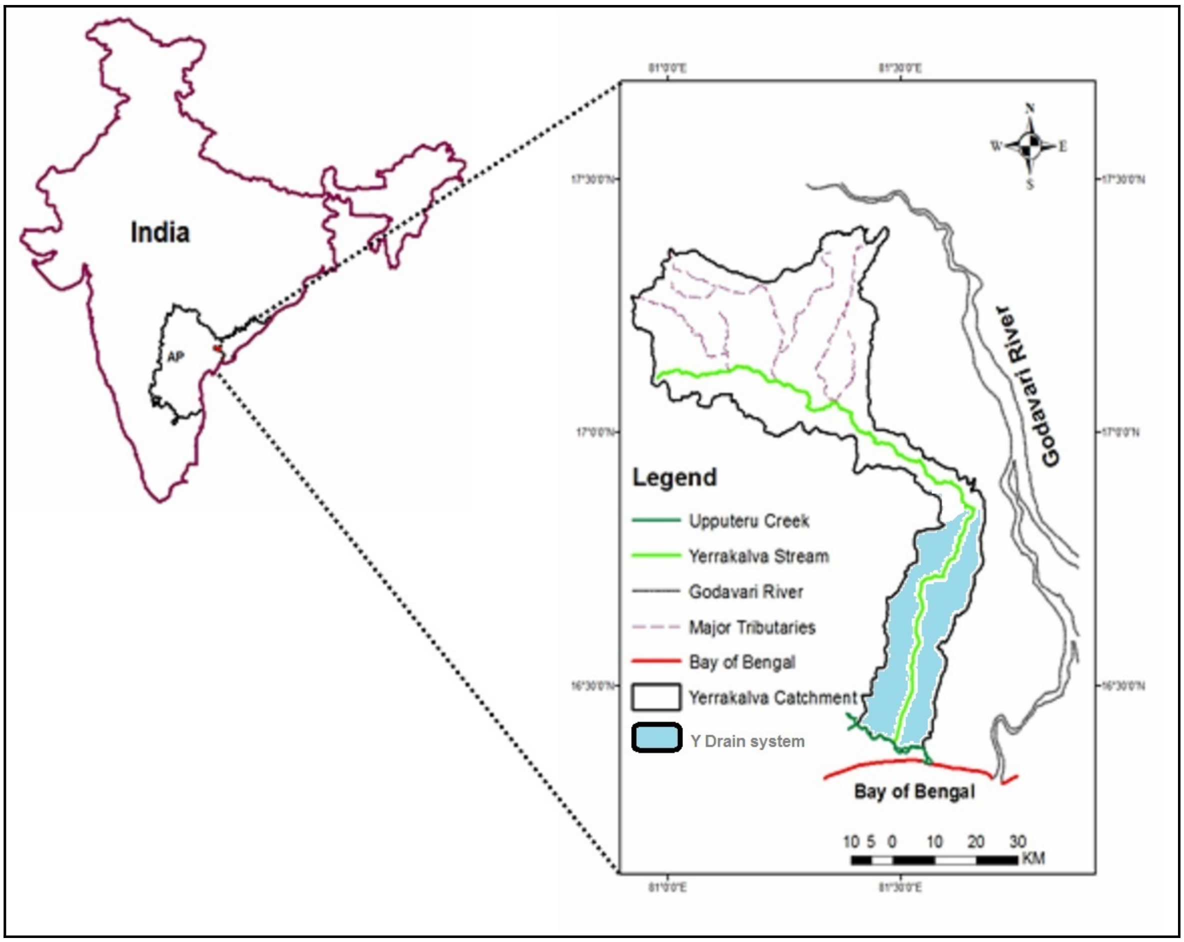

Fig. 1. Study area of Y drain in the Errakalva Basin in Andhra Pradesh

Geology, Soils and Land use

The river traverses over a wide variety of geological formations from Archeans to Recent origin. The important landforms of the Errakalva basin include are structural hills, pediplain, pediment inselberg complex, coastal landforms and valley fills. Different soils encountered in the basin area red soils, black soils, deltaic soils, alluvial soils and coastal sands. Red sandy soils cover the major portion of the basin. The acid granites, gneisses and quartz etc with any subordinate rock types rich in iron and manganese bearing minerals are responsible particularly for formation red soils. Texturally, red soils comprise course sandy loams and fine sandy loams. The deepened soils exhibit sandy loam texture at the surface, with a loams composition in the deeper layers. In contrast to black soils, red soils are light textured, sufficiently permeable to be well drained, have a low water retention, negligible salt content, base status and almost free from carbonates. Red soils are deficit in organic matter and plant nutrients in general, but however respond well to manuring and irrigation. They are referred to as hungry and thirsty soils as they need plant food and water liberally. The crops raised in these soils are generally tobacco, chilies, and paddy, to some extent banana. Black soils can be texturally classified as heavy clays and clay loams. Light loams cover a small portion of the upland area of the basin. The soils in the delta area, comprise mostly clay loams and in a small portion on heavy clays.

3.0 ANALYSIS

A field survey is made in September and December 2014 to collect water samples of precipitation, canal water, groundwater from dug wells and hand pumps and at different location along the 45 km stretch of the stream in an area of 394.93 km^2 in deltaic plain in the Yanamadurru drain or Y drain in the Lower Erra kalva river basin. The timing coincides with the monsoon and post monsoon season in the area. The location of the study area is shown in Figure 1. Rainwater is collected from Undrajavaram, Attili, Palakoderu, Bhimavaram and Mogalturu. Canal water is collected at Canal water at head and tailend. Stream is monitored at Duvva, Minavalluru, Gollalakoderu on Y drain and at Vendra railway station on Gosthanadi drain. Groundwater from hand pumps at Arulla on the upland and at Degampuram towards coast and from dug wells at Suryarao Palem, Duvva, Venkatarajapuram, Mypa, Palakoderu, Bhimavaram, Yanamadurru on left bank and Muddapuram, Minavilluru, Pippara, Yandagandi, Gollakoderu and Bhimavaram on Right bank of Yanamadurru drain. Also dugwell from beach ridges at Mogalturu is also monitored. A water sample from freshwater fish tank near Yandgandi representing higly evaporated water body is also collected. The samples were collected over a stretch of 40 Km from Arulla to Degampuram from head to tail along the Yanamadurru drain. The water samples are collected in September and December 2014. The paper presents the variation of stable isotope $^{18}O_{16}$ in the surface and ground waters of the lower part of Errakalva basin called Yanamadurru drain or Y Drain system. Efforts were made to avoid any contamination, evaporation and effect of exchange with atmosphere. The procedure of sampling water for deuterium and oxygen-18 analyses is very simple. A very small amount of sample is enough. But to be on safer side and for repeated measurements a minimum of 20 ml sample is collected in a HDPE bottle. While collecting samples, groundwater from tube wells and hand pumps, water was left for sufficient time so that the sample represents groundwater of the aquifer understudy. The sample bottles were sealed with wax and transported to laboratory for isotopic analysis. The physical properties of water are measured in-situ. The variation in electrical conductivity is shown in Table 1 and Table 2.

In canal water, EC is in between 190 to 270 during the study period. In the stream water of Y-drain, it is between 380 to 840 during monsoon and 900 to 1310 during post monsoon. On the Gosthanadi drain, a tributary of Y drain it is about 1660 during post monsoon.

Table 1. Variation of EC in surface water in Lower Errakalva (Y Drain) study area

Source	Canal			Stream			
Location	Duvva Channel	Undi Channel	Jagannadha Puram	Errakalva-Duvva	Yanamadurru Drain at Minavilluru	Gostanadi drain	Golla Koderu G/s
Sep-14	190	270	230	270	380	-	840
Dec-14	190	200	250	200	900	1660	1310

Table 2. Variation of EC in groundwater in Lower Errakalva (Y Drain) study area

Source	Hand pump		Dug wells						
Location	Aarulla	Degampuram	Surya Rao Palem	Duvva	Meena Valluru	Yandagandi	Pala Koderu	Bheemavaram1	Mogalturu
Sep-14	1890	5600	2100	3400	1290	1030	930	1210	1140
Dec-14	1850	6300	870	3200	1370	1060	2100	1190	1870

In groundwater, EC is varying from 930 to 5600 during monsoon and from 870 to 6300 in post monsoon. It can be observed that the EC of canal water has not changed much from September to December 2014. However, the same in stream water during post monsoon season increased considerably in the lower reaches due to reduced stream flows as most of them are diverted from Duvva regulator on Y drain through Venkayya-Weyyeru canal. However, EC of groundwater improved in upstream due to canal recharge, whereas, it has not improved at many locations even during post monsoon in other locations. In the Undrajavaram, Attili, PalaKoderu, Bhimavaram mandals rainwater samples were collected. The samples are being analysed for chemical and stable isotope characterization at laboratories at Kakinada and Roorkee. The variation electrical conductivity of canal water, groundwater from dug wells, groundwater from hand pumps, river water and tanks water and its variation from monsoon to post monsoon is shown in Fig 2. The results show that the EC of groundwater is distinct from surface waters. The variation of EC in groundwater in hand pumps is less in the uplands near Arulla and changed significantly in the costal area near Degampuram. Also, it is observed that due to reduction in surface water flows from up stream, due to diversions, the electrical conductivity of river water is deteriorating by post monsoon in the down stream with the increase in EC at Gollakoderu on the Errakalva river, also called Yanamadurru 'drain' by irrigation authorities. Not only reduction in stream flows but also effluents from drains and industries are resulting in increase in electrical conductivity. Further study from other chemical and isotope characterization during both the seasons will help in quantifying the proportion of mixing of canal water and groundwater in the river flows down stream. The findings will be submitted as technical report by 31st March 2015.

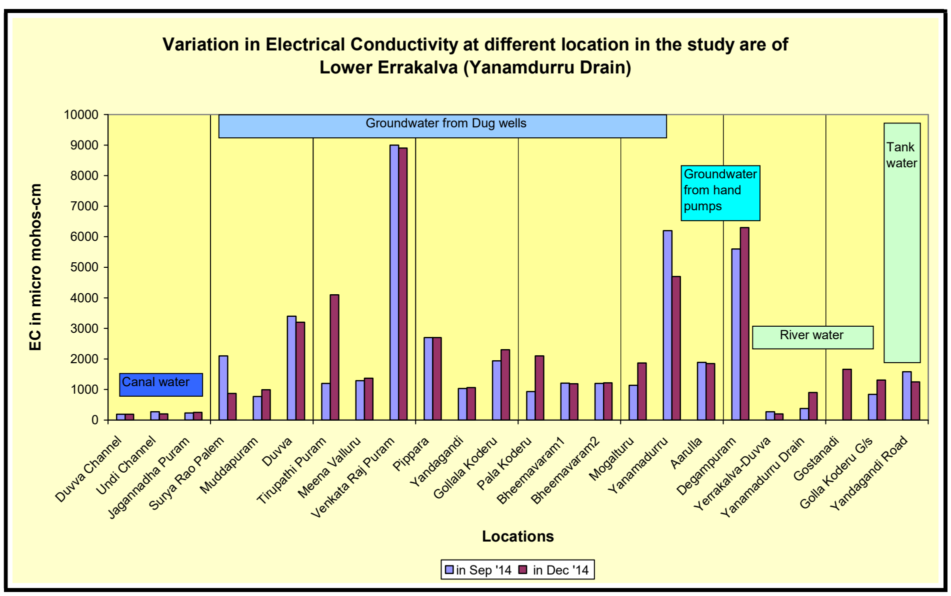

Fig. 2 Electrical conductivity of canal water, groundwater, river and tanks water and its variation from monsoon to post monsoon in lower Errakalva River

Isotope Characterization

The samples were analyzed for δD and δ^{18}O stable isotopes using Continuous flow isotope ratio mass spectrometer and Dual inlet isotope ratio mass spectrometer available at NIH, Roorkee. The measured error in estimates is $\pm$ 0.1 $‰_0$ in δ^{18}O and is $\pm$ 1.0 $‰_0$ in δD. The standards of measurement for stable isotopes are at the zero pivot points. Samples containing a greater proportion of the heavy isotopes have positive δ values; Samples with smaller R-value than the reference have negative δ values with respect to the reference. Rainfall is collected at Kakinada which is about 100 Km from the study area. The same is considered as representative of local precipitation of the study area.

Meteoric Water Line

Water and solutes found in various segments of the hydrological cycle or the same segments during different seasons or under different climatic conditions, would show useful variation in their concentrations because of the isotope fractionation process. One can notice measurable differences in isotopic character and reasonable explanations are at hand for such observation of variations in the nature. Dansgaard (1964) conducted one of the earliest studies of the δ^{18}O in precipitation. Here, δ value is the most common way to express the difference in isotopic composition between a sample and a reference with a ratio of R-value, which is a reference standard for the substance. This difference is most commonly expressed in terms of parts per thousand or permil (‰) and is symbolized by δ. The relation between δD and δ^{18}O that has been observed in global precipitation is expressed mathematically by the equation known as Global Meteoric Water Line (GMWL)

$$\delta D‰ = 8\ \delta^{18}O + 10 \qquad (1)$$

The relation between δD and δ^{18}O can be written in a standard form as a linear equation

$$\delta D‰ = A\ \delta^{18}O + d \qquad (2)$$

Where A is the 'slope' and d is the 'intercept' or 'D excess' of δD Vs δ^{18}O line of fresh global meteoric waters. One can develop regional and local meteoric water lines on the pattern of standard relationship between δD and δ^{18}O valid on regional or local levels.

Deviation in Meteoric Water Line

A complicating factor for deviation in meteoric line is the cloud formation and precipitation. During cloud formation and during precipitation droplets becomes sufficiently large in descent, they may evaporate and exchange water molecules with the air below the clouds. Low-level moisture may be isotopically distinct from upper level moisture. In addition, on its way down through the air the droplet is likely to encounter air with the humidity less than 100%. Thus evaporation from the droplets occurs which is a fractionating process. Thus, the first precipitation droplet to fall through dry air is likely to show kinetic isotopic enrichment. Their values would fall to the right of the global meteoric line. According to Kumar et. al (2010), Indian Meteoric Water Line is

$$\delta D = 8.2\ \delta^{18}O + 9.8\ ‰ \qquad (3)$$

The other process that can move waters to the right of meteoric line is oxygen isotope exchange with carbonate or silicate rocks. Water can have a varied history including oxygen fractionation between various types of rocks at significant depths in the earths crust. Waters discharged from volcanoes and hot springs help us to study directly the isotopic composition of deep geothermal waters. Craig (1961) demonstrated through oxygen and hydrogen isotopic determination that the majority of hot springs is dominated by meteoric water. Interaction of deep water with rocks causes the $\delta^{18}O$ values of the rocks to decrease and $\delta^{18}O$ values of the waters to increase. This oxygen isotope shift in the $\delta^{18}O$ is attributed to progressive equilibration of oxygen in water with silicate and carbonate rocks. Interaction with silicate rocks will cause the $\delta^{18}O$ values of the waters shifted to higher $\delta^{18}O$ values but will not significantly affect the δD values of the water due to low content of hydrogen in most of carbonate and silicate rocks. According to Gibson et al (2002) models developed through combined use of physical, isotopic and geo-chemical tracers, can effectively label water sources, pathways and processes.

Stable isotope characterization

The 'slope' of the line corresponding to $\delta^{18}O$ versus δD of water undergoing evaporation decreases as humidity decreases. That is the slope of standard meteoric line of 8 can range between 8 and 3 in the case of evaporation depending on the relative humidity. The result of this is that residual liquid water that has undergone evaporation plots to the right of the meteoric water line 'LMWL' following a slope of 3 to 8. Waters that have experienced the greatest evaporation factor are farthest from the meteoric line. The slope of this divergent line indicates the relative humidity during the evaporation process. Waters of Closed Basins must have undergone evaporative fractionation.

In this study, the variation of $\delta^{18}O$ in canal water, stream water, groundwater from headwaters to tail end in the study area is analysed for its change from monsoon, or from September to postmonsoon or till December during 2014. As discussed earlier the water occurring in the form of stream flow, canal water, both shallow and deep groundwater must originate from precipitation or from recharge from evaporating water bodies like reservoirs or tanks in the head waters or from ultimate destination of all waters i.e, oceans at tail end, i.e at river mouths and coasts.

4.0 RESULTS & DISCUSSION

The δD vs δ^{18}O plot for LMWL and best-fit lines for ground water during the study period and using precipitation of Kakinada is shown in Fig. 3. The δD vs δ^{18}O of different types of water samples of river water, canal water, ground water, precipitation at Kakinada of Septemebr 2014 are also shown in Fig. 3. The ^{18}O values of different types of waters are shown as graph plot as shown in Fig. 4.

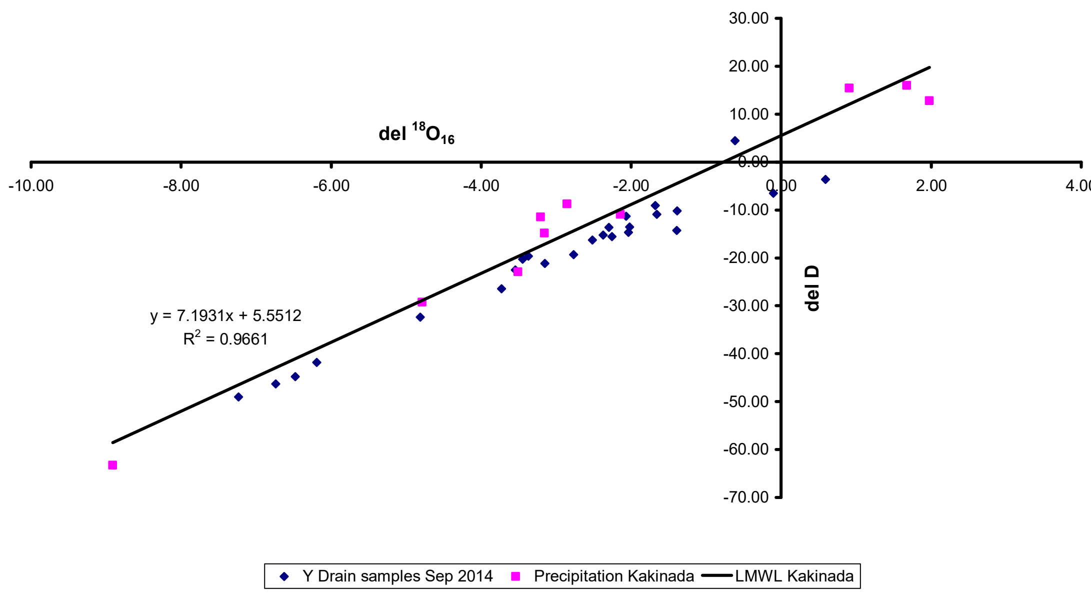

Fig. 3. LMWL along with δ^{18}O and δD variation for water samples in Y drain area

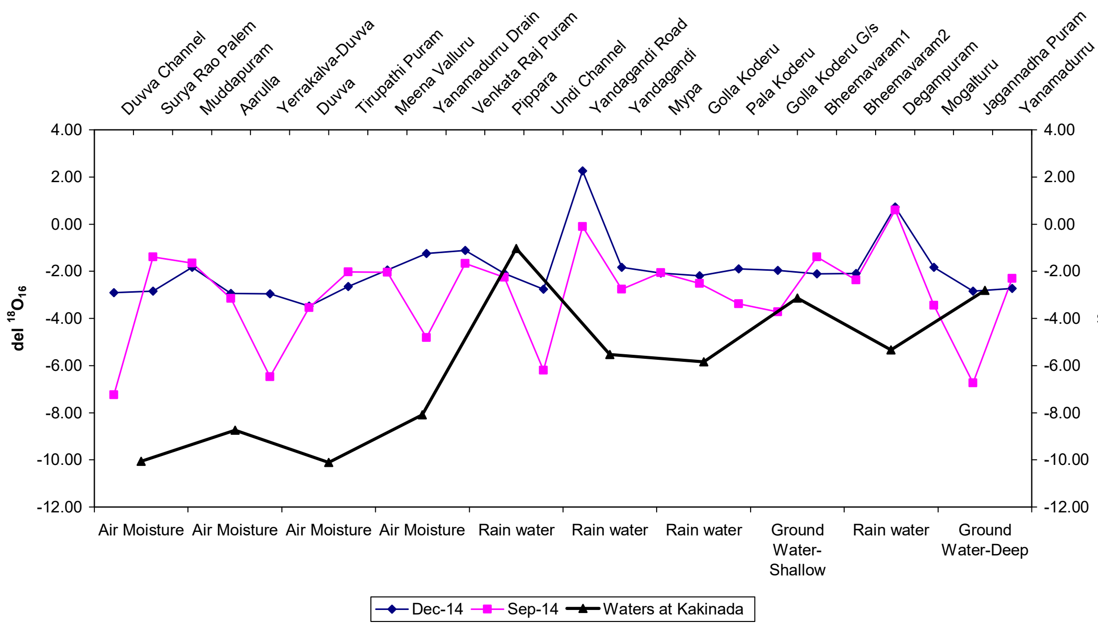

Fig 4. Variation in $\delta\,^{18}O$ isotope in different waters at various locations during 2014

Composition of precipitation and evaporated water in the study area

The water samples collected in the study area are having sources either from rainfall or from water bodies under evaporation. The same is studied by isotope mass balance method using $\delta\,^{18}O$. Also, surface water and groundwater interaction may be studied by groundwater modeling, channel water balance, isotope mass balance method and/or by statistical method using the river and groundwater water level fluctuation data.

The approach is based on the fact that if the rivers originates at higher altitudes and has a different stable isotopic composition than that of groundwater that is recharged by infiltration of local precipitation then stable isotopes can be used to understand river and groundwater interaction. In most of the cases, the stable isotope ^{18}O is utilized for determining the contribution of groundwater to the river flow. For example, the isotopic balance and mass balance equations of an admixture of rainwater and evaporated water or tank water or ponded water in a sample can be written as

$$mt.Rt + mr.Rr = Ram \qquad (4)$$

$$mt + mr = 1 \quad (5)$$

where, Rt and Rr are the isotopic composition of the tank water and the rain water respectively and mt and mr are the fractions of tank water and rain water respectively in the admixture, Ram is the isotopic composition of the admixture in sample. From the above two equations, we have

$$mr = (Ram - Rt) / (Rr - Rt) \quad (6)$$

$$mt = (Ram - Rr) / (Rt - Rr) \quad (7)$$

Therefore, by knowing the value of Rt, Rr, and Ram, the fraction of rain water mixed with tank or ponded water can be evaluated. The proportions of rainfall and evaporated or ponded or tank water for all water samples and their variation from monsoon to post monsoon in the Y drain area is in Table 3.

Table 3. Proportion of mixing of precipitation and ponded evaporating water bodies from $\delta\,^{18}O_{16}$ isotope in the study area in September and December 2014

Type of water	**Del $^{18}O_{16}$**		**Evaporating water surfaces influence %**		**Precipitation influence %**	
	Sep 14	**Dec 14**	**Sep 14**	**Dec 14**	**Sep 14**	**Dec 14**
Rainwater	-7.5	-4.69				
CANALS						
Canal water at head	-7.23	-2.9	3.34	33.09	96.66	66.91
Canal water at tail	-6.74	-2.85	9.39	34.01	90.61	65.99
STREAMS						
YDrain at Duvva	-6.48	-2.96	12.61	31.98	87.39	68.02
YDrain at Minavalluru	-4.81	-1.24	33.25	63.77	66.75	36.23

YDrain at Gollalakoderu	-3.73	-1.97	46.60	50.28	53.40	49.72
Gosthanadi drain at Vendra RS	-	-2.08	-	48.24	-	51.76
GROUNDWATER						
Handpump GW at Arulla	-3.15	-2.96	53.77	31.98	46.23	68.02
Handpump GW at Degampuram	0.59	0.72	100.00	100.00	0.00	0.00
GW Suryarao Palem (L)	-1.39	-2.85	75.53	34.01	24.47	65.99
GW Muddapuram (Right)	-1.66	-1.82	72.19	53.05	27.81	46.95
GW at Duvva (L)	-3.55	-3.48	48.83	22.37	51.17	77.63
GW Minavilluru (Right)	-2.04	-1.95	67.49	50.65	32.51	49.35
GW at Venkatarajapuram (L)	-1.68	-1.12	71.94	65.99	28.06	34.01
GW at Pippara (Right)	-2.26	-2.1	64.77	47.87	35.23	52.13
GW at Yandagandi (Right)	-2.77	-1.84	58.47	52.68	41.53	47.32
GW at Mypa (L)	-2.07		67.12		32.88	
GW at Gollakoderu (Right)	-2.52	-2.19	61.56	46.21	38.44	53.79
GW at Palakoderu (L)	-3.37	-1.9	51.05	51.57	48.95	48.43
GW at Bhimavaram (L)	-1.39	-2.1	75.53	47.87	24.47	52.13
GW at Bhimavaram (Right)	-2.37	-2.1	63.41	47.87	36.59	52.13
GW at Yanamadurru (L)	-2.3	-2.73	64.28	36.23	35.72	63.77
GW at Mogalturu (L)	-3.45	-1.85	50.06	52.50	49.94	47.50
STORED WATER						
Evaporating bodies (Tank)	0.59	0.72	100.00	100.00	0.00	0.00

From the table whereas precipitation or rainfall has its 100% source from rainfall and Tank water or continuously evaporated water fro ponds or water bodies is 100% source from tank water. With this concept, the fraction of rainfall or precipitation in the canal water has decreased from 97% to 67% at the head of canal by end of monsoon and at tail end its proportion changed from 90% to 60% by December 2014. At 10 km down stream from Duvva regulator, from where waters are diverted to other canals, the fraction of rainfall or precipitation in the Yanamadurru drain or Y drain at Minavilluru drastically decreased from 67% to 36% by end of monsoon and shows the impact of diversions or reduction of river flows. The stretch further down stream in the Y drain the situation slightly improved upto Gollakoderu may be due to the flows from irrigation return flow under the canal system. In contrast, the contribution to groundwater which was from evaporated sources as such as tanks and other water bodies in September has changed to that from precipitation by the end of monsoon season. At Arulla, in the groundwater from hand pump the fraction from precipitation increased from 46% to 68% by the end of monsoon season. In general, the wells located in upper parts of the study area have shown such influence better may be due to denser canal network than the wells located in lower reaches where again the impact of irrigation return flows and reduced canal flows at tail end. This indicated that $\delta^{18}O_{16}$ is a useful parameter to characterize the fraction of source waters in the various types of waters sampled from the study area. The same can be taken advantage in managing the regulation of down stream releases and to undertake IWRM plans to maintain the proper river flows to maintain down stream river ecosystem in the Yanamadurru drain in the Errakalva river basin.

5.0 CONCLUSIONS & RECOMMENDATIONS

The results show that the EC of groundwater is distinct from surface waters. The variation of EC in groundwater in hand pumps is less in the uplands near Arulla and changed significantly in the coastal area near Degampuram. Also, it is observed that due to reduction in surface water flows from up stream, due to diversions, the electrical conductivity of river water is deteriorating by post monsoon in the down stream with the increase in EC at Gollakoderu. Not only reduction in stream flows but also effluents from drains and industries are resulting in increase in electrical conductivity.

Application of environmental isotope methods is a good investigation tool available to understand the origin of sources of surface and groundwater with respect to its recharge based on the spatial and temporal variability of the isotopic contents of water. In this paper, variation of measurement of stable isotopes of Deuterium and Oxygen in the water samples of precipitation, canal water, stream water, tank water and groundwater of Yanamadurru drain or Y drain that drains an of 394.93 km2 in deltaic plain is studied and analysed. The results showed that the variation of stable isotope of oxygen and its characterization in different types of water samples can be used as an index to estimate fraction of different sources of water. This methodology is useful to investigate, plan manage impacts of upstream diversion on the lower reaches in river systems elsewhere in similar climates.

Any uncoordinated adjustments in managing available surface water from rivers, frequently contradict measures taken at the macro level or even make them irrelevant. So, responses to augment the supply from existing sources mostly by increasing the quantity of controlled water as well as tapping additional sources. Such plans may be undertaken by constructing new dams or sinking more tube wells and by diverting water from neighboring basins, desalinizing seawater, artificially recharging groundwater etc.

Such investigations help identify such interaction and contributions of rainwater – canal water – groundwater in the study area as well as similar environments. With this concept, the fraction of rainfall or precipitation in the canal water has decreased from 97% to 67% at the head of canal by end of monsoon and at tail end its proportion changed from 90% to 60% by the end of monsoon season. The stretch between Duvva and Gollakoderu is starved of surface water due to upstream regulation on the Y drain even during flow season. There is necessity to undertake planned releases from Duvva regulator or from the surplus of canals close to the Y drain to maintain reasonable quality of stream flows down stream. On Y drain at Minavilluru the fraction of rainfall has drastically decreased from 67% to 36% by end of monsoon and shows the impact of diversions or reduction of river flows. In contrast, the contribution to groundwater which was from evaporated sources as such as tanks and other water bodies in September has changed to that from precipitation by the end of monsoon season.

Stake holders, especially of canal authoroties and Private industries participation needs to be enhanced to maintain sufficient surface water flows in the middle stretches of Y drain and Gosthanadi drain. This will not only improve sufficient surface water flow but also check the ingress of sea water in lower reaches of Y drain. Thus, $\delta^{18}O_{16}$ and its isotope variation and its characterization in different types of water samples can be used as an index to estimate fraction of different sources of water and plan manage impacts of upstream diversion on the lower reaches in river systems elsewhere in similar climates.

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REFERENCES

CGWB, 2003. Hydrogeological frame work and Development prospects in West Godavari District, A.*P.*, CGWB, MOWR, Government of India.

Craig, H., 1961. Isotopic variations in meteoritic waters, Science **133**, 1702-1703.

Dansgaard, W., 1964. Stable isotopes in Precipitation, Tellus **16, 4**.

Fritz, P. and Fontes, C.H., 1980. Handbook of Environmental Isotope Geochemistry Elsevier **1**, 329-406.

Gibson, J.J., Aggarwal, P., Hogan, J., Kendall, C., Martinelli, L.A., Stichler, W., Rank, D., Goni, I., Choudhry, M., Gat, J., Bhattacharya, S., Sugimoto, A., Fekete, B., Pietroniro, A., Maurer, T., Panarello, H., Stone, D., Seyler, P., Mauricebourgoin, L., Herczeg, A., 2002. Isotope Studies In Large River Basins: A New Global Research Focus Eos, Transactions American Geophysical Union, **83, 52**, 613-617.

Kumar, B., S. P. Rai, U. S. Kumar, S. K. Verma, P. Garg, S. V. V. Kumar, R. Jaiswal, B. K. Purendra, S. R. Kumar, and N. G. Pande, 2010. Isotopic characteristics of Indian precipitation Water Resour. Res., **46**, **W12548**.

Vijaya Kumar, S.V**.**, Rao, P.R., Bhishm Kumar, 2009. Stable Isotope Characterization of Groundwater in a Sandstone Aquifer Journal of Appl. Hydro. **XXII**, **2**.

Vijaya Kumar, S.V., P. R. Rao, T. Vijaya, U. V. N. Rao, Bhishm Kumar, 2011. Stable isotope characterization of groundwater in pushkar canal command area, IJEE Vol. 04, No 08 - Spl issue, December 2011, pp. 17-23

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