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Impact of different cropping systems on properties of soil and water in different micro watersheds

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Abstract Studies on soils of Navsari Agricultural University (NAU) having different cropping system were carried out in the four micro watersheds that exist in the 400 ha University campus. Soil samples from 0-15 cm depth and water samples from adjacent bore wells were collected and analyzed from different locations of micro watersheds. Soils of watersheds showed that soils texture was clay in nature, having more than 65 % clay, whereas silt was more in watershed 'A'. Soil organic carbon content (SOC) was 0.32 %, found in the field near University play ground and the highest 0.88 %, in Forestry farm, thus underlining the need of forest species in agricultural farms. SOC levels have reduced significantly due to intensive cultivation in all the watersheds. The result of exchangeable sodium percent (ESP) is supported by the topographic features, as, ESP was more in watershed 'B' (5.15) than C (2.95), this showed that infiltration rate was lesser in 'B' as compared to 'C' due to availability of more sodium (Na). Available N was highest in watershed 'A' (246 kg/ha) followed by 'C' (225 kg/ha) than 'B' (203 kg/ha), the reason was watershed 'A' had only horticulture crops whereas B and C had different crops of the region. Electrical conductivity (EC) of ground water collected from wells in watershed 'C' was found to be very high both before (3.44 dS/m) and after monsoon (2.95 dS/m), showing that water is highly saline and not fit for surface irrigation and there is need of ground water recharging.

Keywords: Cropping pattern, Soil analysis, Water analysis, Watersheds

INTRODUCTION

Soil, water, vegetation and environment are the prime natural resources on the earth. Among these, soil is the most vital natural resource on which depends the life supporting systems of a country and socio-economic development of its people (Anonymous 1996). Soil is at the heart of terrestrial ecology, but it is finite and non-renewable (Leelavathi *et al.*, 2009). It is the upper most layer of the earth crust which constitutes the medium for plant growth and production of several kinds of goods of agriculture, horticulture and forestry (Naidu *et al.*, 2009). Characterizing soil and climatic constraints for sustainable forest development in Karnataka using Remote Sensing (RS) and Geographic Information System (GIS). Naidu *et al.* (2009) digitized and overlaid the soil and land use cover maps for critical evaluation of soil-site parameters for the growth and development of different forest type. Being a component of lithosphere and biosphere system, soils provide food, fiber, fuel and fodder for meeting the basic human needs. However, the capacity of the soils to produce is limited and the limits of production are set by soils, climatic conditions and management. Bali *et. al.* (2010) studied detailed characterization of soils of Punjab. Kumar *et. al.* (2006) studied soils under different land uses in dry temperate zone of the state and found wide variation in soil pH, available phosphorus, maximum increase was recorded in soils of wasteland and minimum in soils under grasses and maximum increase in available potassium was observed in soils under hops cultivation and minimum in wasteland soils. Based on soil properties land capabilities classes were fixed and suitable land use plan was suggested for sustaining yields of crops in Ramachandrapuram mandal of Andhar Pradesh (Vara Prasad *et al.*, 2008). Ganeshamurthy *et al.* (2009) studied improvement in soil quality due to pulse crops which enriches soil with nitrogen, and they also studied about the impact of continuous cultivation of pulses on soil health.

As the natural resources of any country are the national treasure, we need proper planning to make best use of them. Therefore, suitable management practices are urgently needed to preserve the production potential of agricultural lands. Efficient management and maintenance of soil health/ quality is the key to accomplish sustained high productivity, food security and environmental safety (Tripathi *et al.*, 2006). So, a renewed attention is being given to soils due to rapidly declined land area for agriculture, declining soil

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fertility and increasing soil degradation, wrong land use policies and irrational and imbalance in use of input. Quality of soil depends more on the crops cultivated, irrigation water quality, management practices, topography and weather of the place. Kalra *et al*. (2012) studied for physico- chemical status of ground water in southern parts of district Bhojpur district of Bihar. Negi and Ghosh (1980) evaluated irrigation water quality of the cold and arid region of Himachal Pradesh. All these factors call for a shift in research away from maximum crop production to the "sustainable crop production system" without degradation of soil health and environmental quality. Developing and adopting an ideal land use plan based on the soil quality and constraints for plant growth is of immense use for achieving the goal. Therefore, characterization, classification and evaluation of soils for different land uses are the first milestone to develop sustainable and eco-friendly land use model. Keeping this in view, the present investigation was conducted to study the impact of different cropping systems on properties of soil and water in different micro watershed.

MATERIALS AND METHODS

The study area is in Navsari Agricultural University campus that lies between 20^{0}57'6.77N latitude and 72^{0}55'17.38E Longitude. It is located in the coastal South Gujarat which is classified as heavy rainfall agro climatic situation. The region is characterized by hot summer, moderately cool winter with humid and warm monsoon period (June to September), having 1500 mm average rainfall. There are four micro watersheds in the campus, out of which two of them B and C cover the major part of University campus. Vegetative cover in micro watersheds depend upon cropping systems adopted as per the mandate of individual departments. To evaluate changes due to the existing land uses, a total 17 soil samples and 12 water samples from different watersheds (Table 1) of the University representing different land uses were collected. The physico-chemical analysis and water analysis was carried out following standard methods of analysis (Subbiah and Asija, 1956; Jackson 1973).

RESULTS AND DISCUSSION

Mechanical analysis of surface soils (0 to 15 cm) of watersheds of NAU campus (Figs. 1, 2) showed that soils were clay in nature, having more than 65 % clay content (Fig. 3). Coarse sand was less in Watershed, A, as compared to other two Watersheds. Fine sand was more or less the same in all the three watersheds, whereas silt was more in Watershed A as compared to B and C, the reason being, during monsoon flooding, natural drains which flow along the periphery of watershed brings lot of silt from upstream areas and that silt got deposited in fields of Watershed A.

The data showed that University play ground, contain highest coarse sand, 8.20 %, whereas, forestry farm having Eucalyptus plantation, had lowest 1.83 %. The highest fine sand, 17.43 % was observed in Jatropa field and lowest fine sand, 11.3 %, was found in National Agricultural Research Project (NARP) farm cultivating paddy. The highest value of silt was recorded from pulses research station 20.40 % and the lowest from Sapota plantation which was surrounded by buildings. The highest clay was observed in NARP banana, 74.23 %, and the lowest in Jatropa field, 59.87 %.

Table. 1. Study sites for sampling of soil and water.

Watersheds	Site for soil analysis		Site for water analysis
A	1	Mango orchard behind girls hostel	
B	1	LRS grass land	Sugarcane farm
	2	University play ground	Horticulture
	3	Sapota field in front of VC bungalow	Grass land
	4	Eucalyptus plantation forestry college	VC bungalow
	5	Sugarcane farm	Forestry college
	6	Horticulture mango	ASPEE college
C	1	Jatropha field	NARP farm
	2	Water management oil palm Plantation	forestry farm
	3	Teak forestry farm	Organic farm
	4	NARP farm	Water management banana
	5	Pulse research station	Jatropha
	6	Organic banana farm	Pulses
	7	Water management farm banana	
	8	Forestry farm eucalyptus Plantation	
	9	Forestry farm Kalam	
	10	Horticulture Sapota	

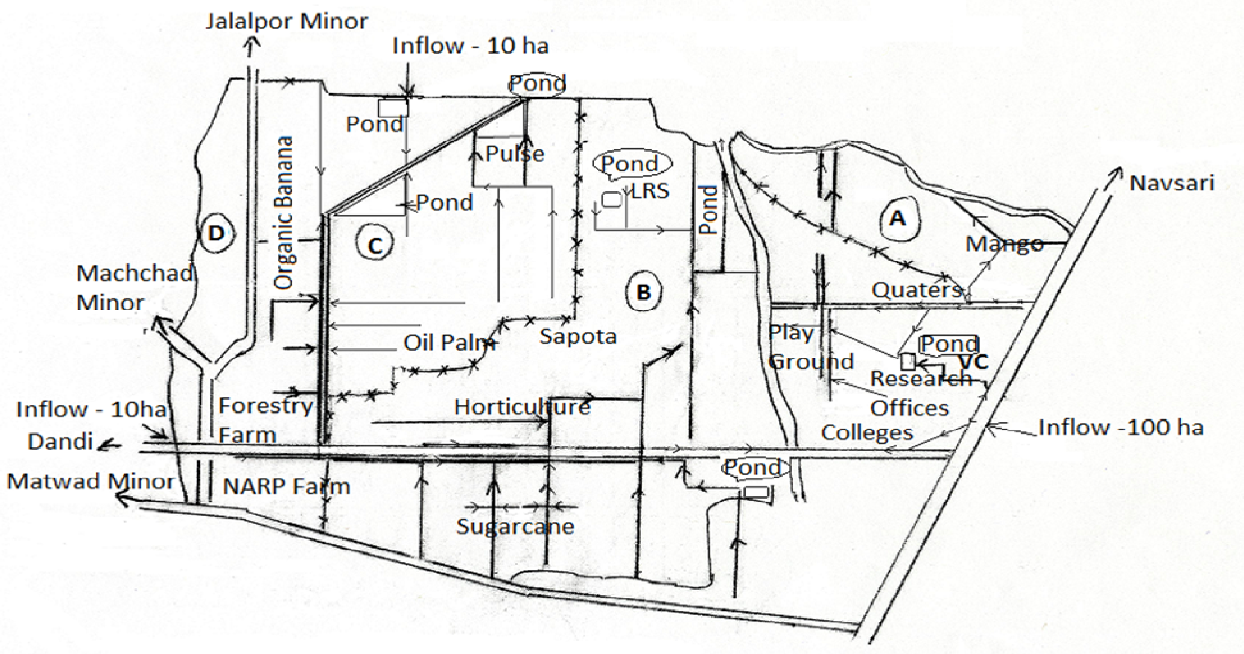

Fig. 1. *Watersheds in NAU Campus.*

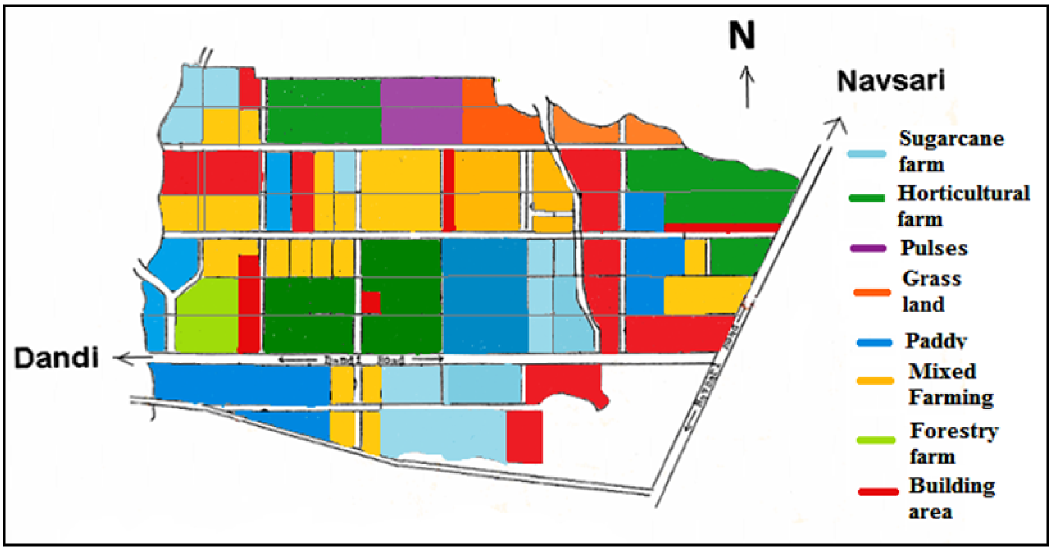

Fig. 2. *Current land use pattern in NAU campus.*

The results prove that in kyari lands, where paddy was cultivated had highest clay content, in the areas where natural drains overflow had more silt and building and play grounds had more coarse sand. Samples were collected from different watersheds having different cropping patterns (Table 1) and depicted in (Fig. 2). It showed that soil pH in all the watersheds increased after monsoon, the trend line show the highest slope (0.23) in Watershed A and minimum slope (0.05) in Watershed 'C'. There was minimum change in soil pH in C as drains were at distance in the Watershed 'C', whereas, in Watershed A and B, deep natural drains were there along the periphery (Watershed A) or at the center (Watershed B).

The pH data (Fig. 4) indicated that before monsoon and after monsoon the lowest value of soil pH was 6.98 and 6.88 in Horticulture farm having mango trees and in front of VC bungalow Sapota fields respectively, both areas come in Watershed 'B'. Whereas, the highest pH before and after monsoon was 8.08 and 8.15 respectively in Eucalyptus plantation of Forestry College, watershed 'C', in this area also there was a deep natural drain along the periphery of plantation. The soils of the Watersheds of NAU campus showed that pH ranges from 6.88 - 8.5 indicating neutral to alkaline in reaction.

After monsoon, Fig. 5, soil EC comes down to 0.35 dS/m in all the watersheds, before monsoon it was around 0.55 dS/m in watershed A and 0.40 dS/m in watershed B. After monsoon the lowest EC 0.22 dS/m was recorded in fields of Sapota in front of VC bungalow, due to leaching of salts in nearby pond. The highest

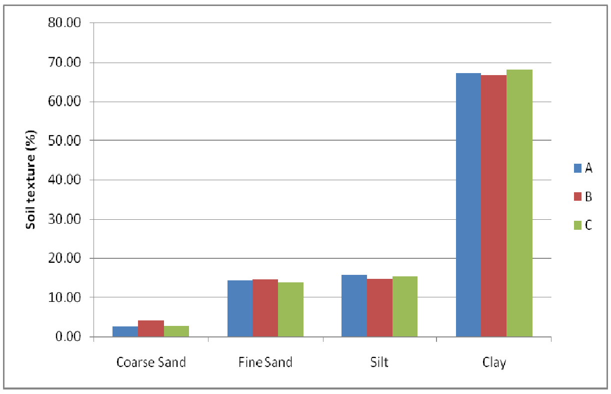

Fig. 3. *Soil texture of watersheds of the campus.*

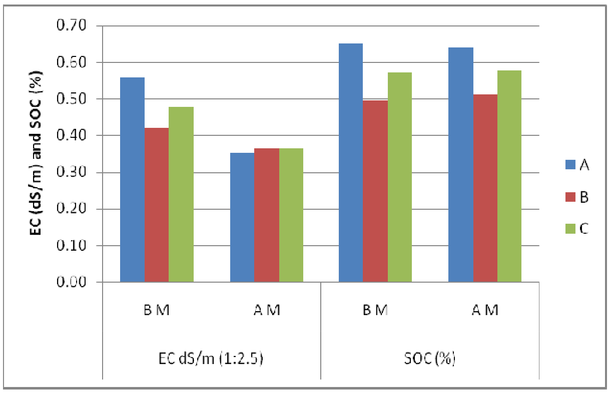

Fig. 5. *Changes in EC and SOC before and after monsoon.*

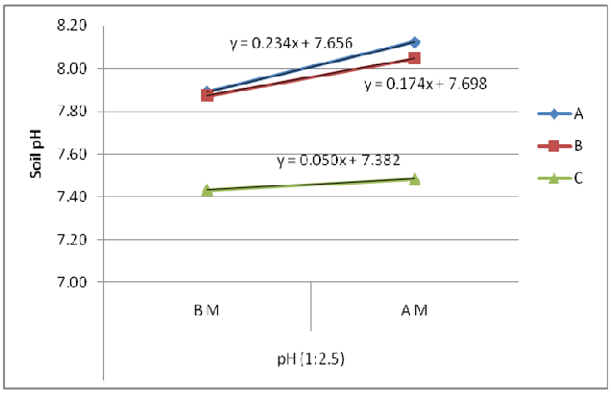

Fig. 4. *Changes in soil pH before monsoon (BM) and after monsoon (AM).*

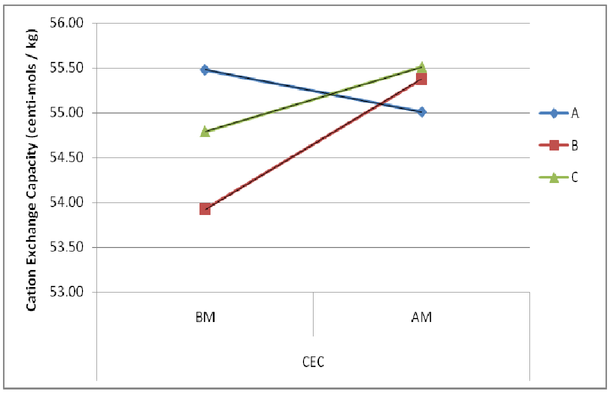

Fig. 6. *Cation exchange capacity of watersheds, before and after monsoon.*

EC (1.07 dS/m) before monsoon was found in fields of oil palm and Soil water management research unit. After monsoon, the highest value of EC 0.53 dS/m was found in the soils of Sugarcane Research Station, watershed 'C'.

Soil organic carbon content (SOC), Fig. 5, does not show any effect of monsoon. It was highest in Watershed 'A' and lowest in Watershed 'B', where, crops like paddy, sugarcane, banana, mango and sapota are cultivated. All the watersheds of the campus showed low to medium SOC content. The lowest SOC of 0.32 % was found in the field near University play ground and the highest 0.88 %, in Forestry farm. This underlines the need of forest species in agricultural farms for increasing soil organic carbon (Gupta, 2012). Since intensive cultivation was there in all the watersheds, the SOC levels have reduced significantly.

Cation - exchange capacity (CEC) is the maximum quantity of total cation, of any class, that a soil is capable of holding, at a given pH value, available for exchange with the soil solution. CEC is used to measure fertility, nutrient retention capacity and the capacity to protect groundwater from cation contamination (Poonia, 2002). One way to increase CEC is to favor the formation of humus, in general, higher the CEC, the higher the soil fertility. Fig. 6 shows that CEC in watershed 'A' decreased after monsoon, 55.48 (BM) to 55.01 (AM); whereas it increased in Watershed 'B' 53.92 (BM) to 55.38 (AM) and Watershed 'C' 54.79 (BM) to 55.51 (AM); CEC deteriorates in Watershed 'A' due to flooding and loss of humus from the area. Rate of improvement in Watershed 'B' was more as compared to 'C', the reason being the Watershed 'B' had horticulture crops.

Fig. 7 showed that ESP (Exchangeable sodium percent) increased after monsoon in all the watersheds, it was highest in Watershed 'A' (6.14) and minimum in Watershed 'C' (2.95), ESP was more in Watershed 'B' (5.15) than C, this showed that infiltration rate was lesser in 'B' as compared to 'C' due to availability of more sodium (Na). The results are supported by the topographic feature also, as Watershed 'C' was at lower elevation than 'B'.

Available N was highest in Watershed 'A' followed by 'C' than 'B', Fig. 8; the reason was Watershed 'A' had only horticulture crops whereas B and C had different crops of the region. Before monsoon the available N was found in range 178 - 289 kg/ha whereas, after monsoon the range of available N was 198 - 278 kg/ha, thus showing that there was slight increase in N after monsoon, it may be because of organic decay of leaves in the soils. Available P_2O_5 was found to be highest in Watershed 'C' and lowest in 'A, it may be because in other cultivated fields, P_2O_5 was added during each cropping season, especially in Watershed 'C', which had more number of short duration crops.

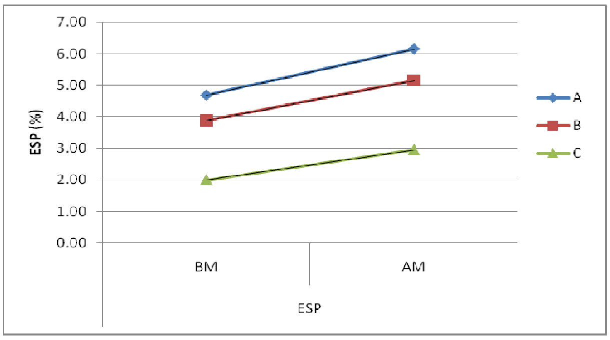

Fig. 7. *Exchangeable sodium percent of watersheds, before monsoon (BM) and after monsoon (AM).*

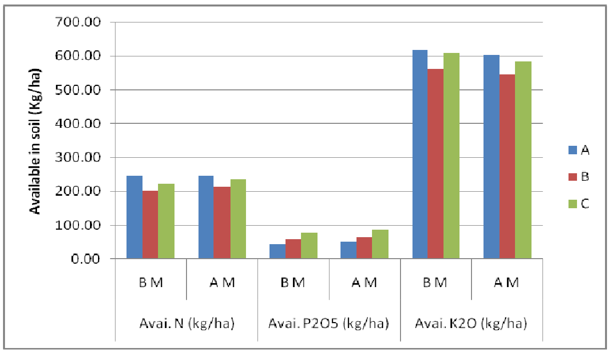

Fig. 8. *Available N, P_2O_5 and K_2O in watersheds, before monsoon (BM) and after monsoon (AM).*

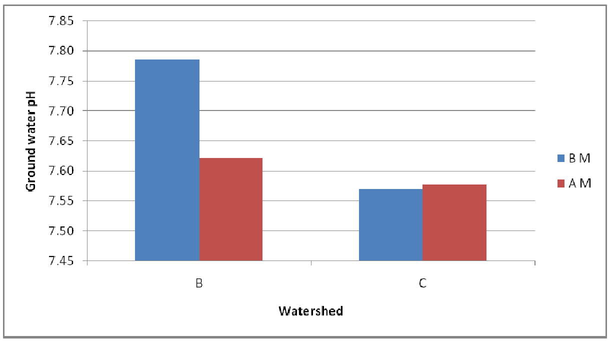

Fig. 9. *pH of ground water of watersheds before monsoon (BM) and after monsoon (AM).*

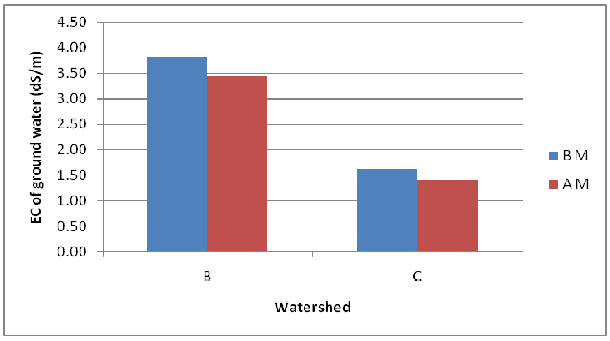

Fig. 10. *EC, dS/m, of ground water of watersheds, before monsoon (BM) and after monsoon (AM).*

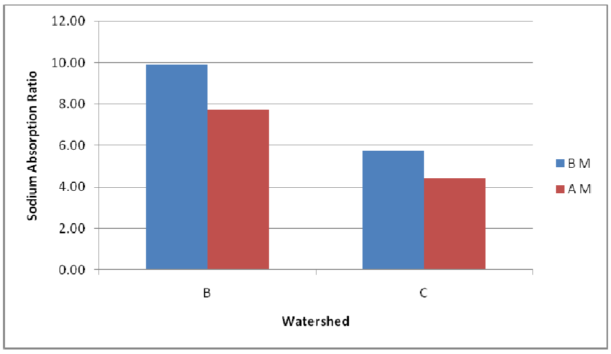

Fig. 11. *SAR of ground water of watersheds before monsoon (BM) and after monsoon (AM).*

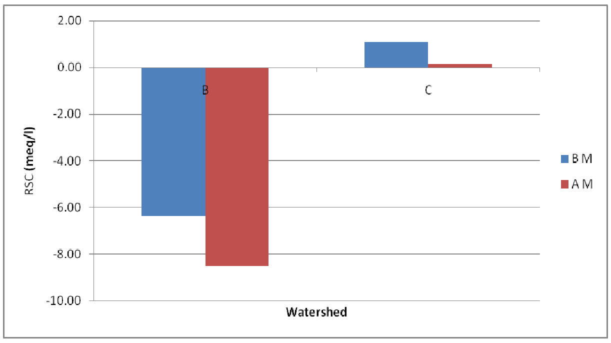

Fig. 12. *RSC of ground water of watersheds, before monsoon (BM) and after monsoon (AM).*

Available K_2O was also found to be highest in Watershed 'A' followed by 'C than 'B', and because negligible K_2O is applied in most of the crops cultivated in watersheds 'B' and 'C'.

Current ground water quality in campus watersheds: Water samples were collected from different wells located in cultivated fields of both the watersheds, seven and five wells were chosen, respectively from Watershed 'B' and 'C'. Fig. 9 showed that in Watershed 'B', pH was much high (7.81) before monsoon (BM) and it reduced to 7.64 after monsoon (AM), whereas, in Watershed 'C', it remained at around 7.58 to 7.56 both before and after monsoon.

Similarly, EC (Fig. 10) of water from wells in Watershed 'C' was found to be very high both before (3.44 dS/m) and after monsoon (2.95 dS/m), showing that water was highly saline and not fit for irrigation through surface method of irrigation (Gupta, 2012). It also implied that there is a need of recharging ground water, judicious use of water, cultivation of less water requiring crop, and ban on tube well digging. Whereas, in Watershed 'C', water quality was found to be lying within the acceptable limits of irrigation. It also implied that better water management practices were being followed in Watershed 'C'.

Sodium adsorption ratio (SAR) of both the watershed was below 10, (Fig. 11) but in watershed 'B', SAR was found to be on the verge of crossing the threshold limit, that showed sodium hazard is eminent in future, if appropriate water management is not followed. Watershed 'C' does not have any such problem, proving that good water management was practiced in the watershed.

Residual sodium carbonate (RSC) was < 0 in watershed 'B' and >0 in watershed 'C', (Fig. 12) which indicated Sodium carbonate was found to be present in ground water of Watershed 'B', this also indicated that saline water was present.

Conclusion

Mechanical analysis of soils of watersheds showed that soils texture was clay in nature, having more than 65 % clay content, whereas silt was more in watershed A, as, overflowing natural drains deposited silt in fields of Watershed A. Due to intensive cultivation, soil organic carbon content (SOC) reduced significantly in all the watersheds, underlining the need for cultivation of forest species in agricultural farms. Cation - exchange capacity (CEC) deteriorated in watershed 'A' due to flooding and loss of humus from the area. Due to cultivation of horticulture crops in watershed 'B', rate of improvement in CEC was more in 'B' as compared to 'C'. Available N was highest in watershed 'A' followed by 'C', due to cultivation of horticulture crops. Electrical conductivity (EC) of well water was very high in Watershed 'B' and was not fit for irrigation through surface method of irrigation. It implied that there is a need of recharging ground water, judicious use of water, cultivation of less water requiring crop, and ban on tube well digging. Sodium adsorption ratio (SAR) of both the watersheds was below 10, however Watershed 'B', showed eminent sodium hazard in future, if appropriate water management practices are not followed.

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