American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-02, Issue-07, pp-41-48
www.ajer.org

Research Paper Open Access

Assessment of Infiltration rate of a Tank Irrigation Watershed of Wellington reservoir, Tamilnadu, India.

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Abstract: - A Study was attempted to assess the infiltration rate of a tank irrigated Wellington watershed of Tamilnadu, India. Different types of soil samples have been collected from 30 locations spread uniformly over study area in order to examine the infiltration rate of soils and its impact on the overall crop production process. Double ring infiltrometer was used to carry out the experimental study. Infiltration rates were taken at 0 to70 minutes of 10 minutes intervals. The assessment or determination of infiltration rate was processed by laboratory analysis of soil samples for the particle size distribution. The infiltration rates were well above the recommended values for crop production. This will help improve the structure and restore soil potentials. Apart from these, suitability evaluation of land in order to effectively categorize soils on the basis of their potential for optimal use could as well be imperative.

Key Words: **-** Double ring infiltrometers, Land use, Soil type and texture, Steady state infiltration and surface irrigation.

I. INTRODUCTION

Precipitation, upon falling on the soil surface, wets it, fills depressions and penetrates into the soil. This water replenishes the soil moisture deficiency with the excess moving downward by force of gravity through seepages or percolation to build up the water table [3]. The phenomenon of infiltration has been variously defined; it entails a process of water movement from surface soil into the ground. This water is said to have the potentials of penetrating into the lower soil profile [8], [16]. Besides, it carries with it some amount of nutrients [11], [2]. Infiltration is the term applied to the process of water entry into the soil. The rate of infiltration determines. The time at which superficial water appears on the soil surface. The amount of runoff that will form over the soil surface during rainfall or irrigation. If the rate of infiltration is limiting, the entire water balance in the root zone will be affected. Infiltration is the process by which water enters the soil. It separates water into two major hydrologic components - surface runoff and subsurface recharge. The assessment of runoff risk has assumed an increased importance because of concerns about the associated pollution hazards. Accurate determination of infiltration rates is essential for reliable prediction of surface runoff. As environmental impact assessments are concerned with long-term effects, it is essential that the infiltration data on which they are based should be reasonably stable over decades. For planning purposes it is essential to know the stability of infiltration data for the infiltration capacity of individual soils is adequate to cope with the anticipated hydrologic loads. A high infiltration rate is generally desirable for plant growth and the environment. In some cases, soils that have unrestricted water movement through their profile can contribute to environmental concerns if misapplied nutrients and chemicals reach groundwater and surface water resources via subsurface flow. In India also, very few studies have been reported that focused on infiltration based rainfall simulator experiment [1], [17]. [12]- [14] have measured run-off and sediment yield over a period of 2–3 years from micro-watersheds in Kumaun Himalaya under the natural rainfall conditions but studies based on simulated rainfall are very rare in the country. A few studies had been carried out by [15], [9], [19], [20] for estimating the infiltration rates in various basins in different parts of India using double ring infiltrometers.

Infiltration of water into the soil has important impact in the overall functioning of the variable land – based activities. It has significant tradeoffs for environmental sustainability, food security, biodiversity stability and susceptibility of soil to adverse environmental conditions. Two factors can greatly undermine availability of water for sustainable crops production *viz*: low water table and impervious layer. The former may be due to excessive infiltration which is often a function of soil characteristic while the later may be largely due to clay deposit that can cause crusting below the soil surface. Infiltration of water into the soil has important impact in the overall functioning of the variable land – based activities. It has significant tradeoffs for environmental sustainability, food security, biodiversity stability and susceptibility of soil to adverse environmental conditions. Two factors can greatly undermine availability of water for sustainable crops production *viz*: low water table and impervious layer. The former may be due to excessive infiltration which is often a function of soil characteristic while the later may be largely due to clay deposit that can cause crusting below the soil surface. The study of infiltration rates come in handy in many hydrological problems such as runoff estimation, soil moisture budgeting and in irrigation planning. Infiltration has an important place in the hydrological cycle. Detailed study of Infiltration process meets the following purposes.

(i) Estimation of peak rates and volumes of runoff in planning of tams, culverts and bridges etc.,
(ii) Estimation of surface runoff and overland flow.
(iii) Planning of watershed engineering
(iv) Estimation of groundwater recharge
(v) Assessment of soil moisture deficits and planning irrigation and drainage system etc.,

II. METHODOLOGY

There are four commonly employed methods and instruments for the measurement of infiltration, namely double infiltrometers; ponding; blocked recirculating infiltrometer; and a deduction of infiltration from evaluation of the advance phase and the tail-water [18]. The ring infiltrometer methods are usually applied in Vellar River basin, while the other two are suitable for furrow irrigation. In a homogenous one-layer soil, water flows relatively uniformly in the vertical direction, with very little lateral drainage. So, measurements done with a single ring infiltrometer could be as accurate as that obtained from a double ring infiltrometer. The soils in the Wellington reservoir area have developed as a result of annual deposition of different layers of sediments. In such multiple layered soils, significant lateral water flow is inevitable and hence, a double ring infiltrometer is preferable. As shown in (Fig.1).water in the outer ring moistens a large surrounding area, creating a buffer to effectively minimize any flow of water from the inner ring in a horizontal direction. Table1. Steady infiltration rates for general soil texture groups in very deeply wetted soil [4]

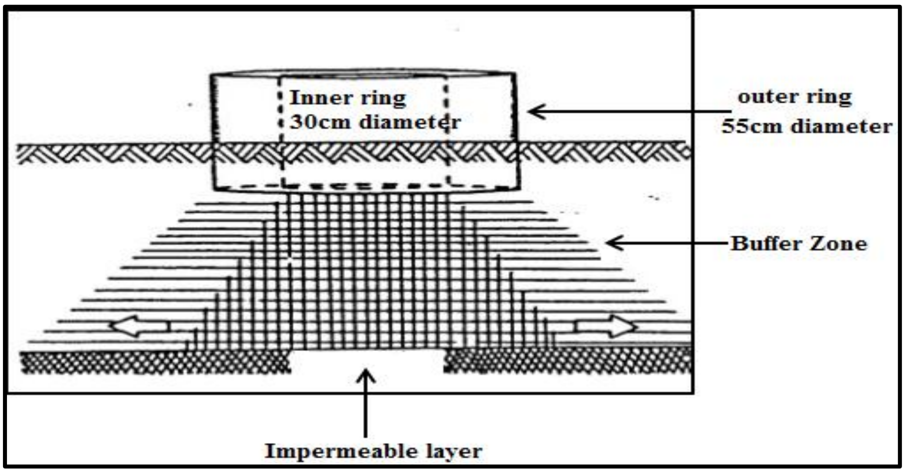

Fig1. Buffering the lateral flow below an double ring infiltrometer [18]

The Study Area

The study area considered is Wellington reservoir watershed which is located in the Tittakudi taluk (Fig 2). It lies between the longitudes of 11˚21’ to 11˚31’ E and latitudes of 78˚57’ to 79˚28’N. The present study area occupies an aerial extent of 100 sq.km and the relief ranges from 62 m to 121 m above MSL. As of 2001 India Census, Tittagudi had a population of 20,734. In this taluk, agriculture area is 823.74 km^2. The study area receives an average rainfall of 1100 mm with more than 80% of the rainfall received during the NE monsoon. The minimum and maximum temperature ranges between 20°C and 34°C in the month of January and May respectively. River Vellar flows in the southern part of the study area. Geomorphologically the area consists of old flood plains, pediments, duricrust and pediments covered by forest land [22]. Black soil is predominant soil type in this area and main occupation of the area is agriculture. The groundwater level of the study area ranges from 2m to 8m bgl (below ground level). The Wellington Reservoir is located in Vellar Basin across a tributary stream Periya Odai of Vellar River. The Reservoir was constructed during 1913-1923 and irrigates an ayacut of 11,200 Hectare. It receives regulated supply diverted from Vellar River at Tholudur regulator and an additional catchment area of 129 $(Km)^2$ of its own during North East Monsoon. Paddy, Sugarcane is the major crops grown in and around wellington ayacut.

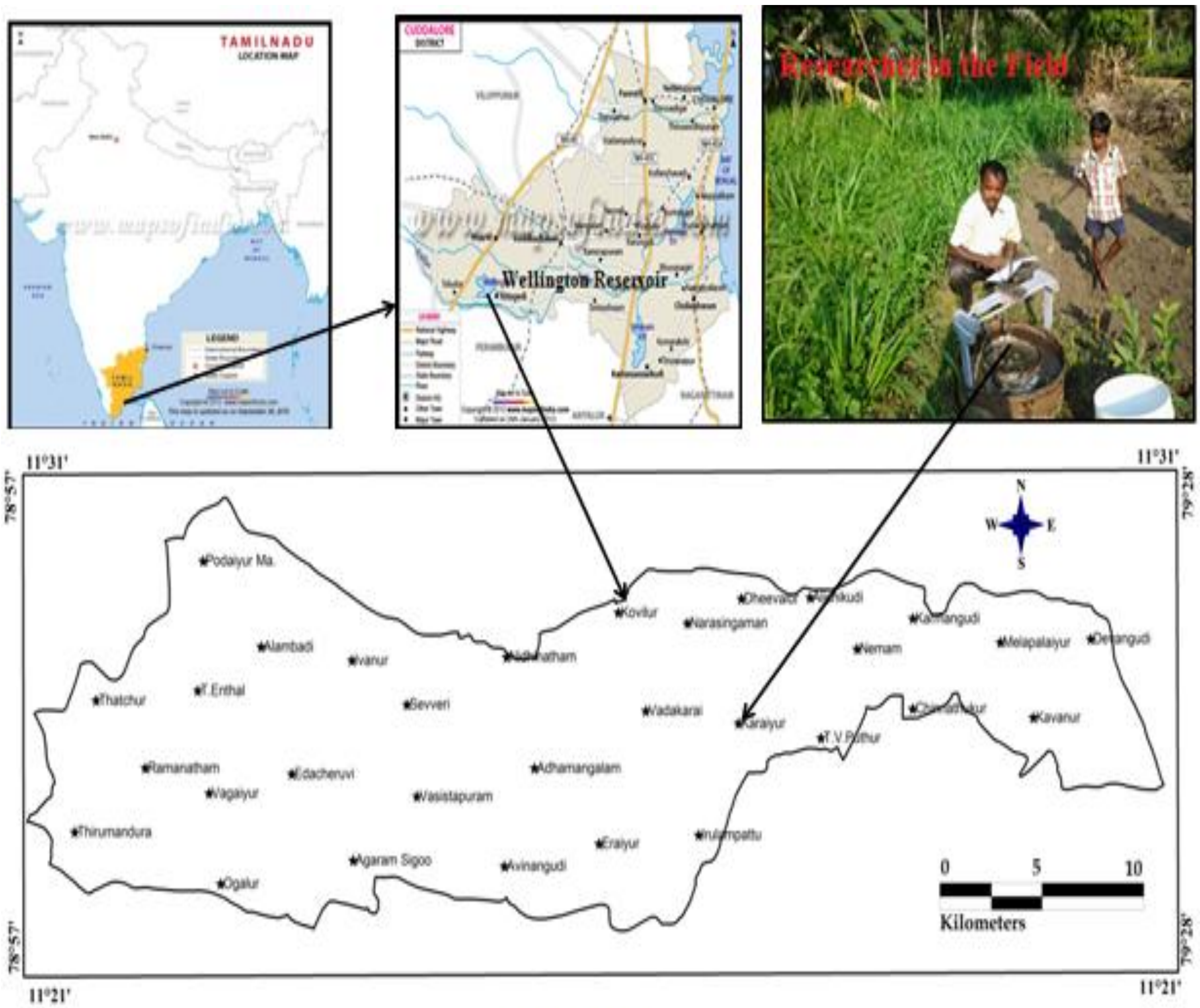

Fig: 2 Study area location map

III. RESULTS AND DISCUSSIONS

The major soils that were identified from soil type maps are well sand, poor sand, poor clay and well clay. (Fig. 3-6)shown in the infiltration rate curves for well sand, poor sand, poor clay and well clay soils, respectively. The measured steady state infiltration rates for the selected soil types are presented in (Table 4) and Steady state infiltration rates for the study area (Fig 8). The initial infiltration rates range from 8.4 – 46.8, 13.2-46.8, 7.2 - 36 and 5.4 – 58.8 cm/hour (Fig. 3-6) while steady state infiltration rates ranges of cultivated land [10] 8.4 – 19.2, 13.2 – 21, 7.2 - 18 and 5.4 – 30 cm/hour, respectively for well sand, poor sand, poor clay and well clay soils, respectively (Table 4). Generally, the lower the initial soil moisture content is, the higher the initial soil infiltration rate will be [7]. This explains the high initial infiltration rates for all the soil types, since the initial soil moisture was expected to be low due to dry soils in winter when the experiments were conducted. The infiltration rate curves for the study area are exponential and asymptotic and are adequately described by the existing infiltration models such as [5]. Infiltration is rapid through large continuous pores at the soil surface and slows as pores become smaller. Steady-state infiltration rates typically occur when soil is nearly saturated and are listed for varying textural classes in (Table 1). These are average values and should not be generalized for all soil types. Guideline of basic infiltration rates infiltration classification for various soil types discussed in (Table 2) and according of [6] basic infiltration rate cm/hr, ratings of infiltration rate for surface irrigation Table 3.

TABLE: 1. STANDARD VALUES OF STEADT STATE INFILTRATION FOR GENERAL SOIL TEXTURE GROUPS [4]

Soil Type	Steady Infiltration Rate (in/hr)
Sands	> 0.8
Sandy and silty soils	0.4 - 0.8
Loams	0.2 - 0.4
Clays	0.04 - 0.2
Sodic clayey soils	< 0.04

TABLE 2: GUIDELINE BASIC INFILTRATION RATES FOR VARIOUS SOIL TYPES (THOMAS ET AL., 2004)

Soil type	Basic infiltration rate in mm hr-1	Infiltration class
Sand	> 30	Very rapid
Sandy loam	20 to 30	Moderately rapid to rapid
Loam to silt loam	10 to 20 Moderately slow to moderately rapid	Moderately slow to moderately rapid
Clay loam	5 to 10	Slow to moderately slow
Clay	1 to 5	Very slow to slow

TABLE: 3 RATINGS OF INFILTRATIONS RATE FOR SURFACE IRRIGATION [6]

Basic infiltration rate cm/hr	Sustainability for surface irrigation.
<0.1	Unsuitable (too slow) but suitable for rice
0.1 – 0.3	Marginally suitable (too slow), marginally suitable for rice
0.3 -0.7	Suitable; unsuitable for rice
0.7 -3.5	Optimum
3.5-6.5	Suitable
6.5-12.5	Marginally suitable (too rapid) small basin Reflowed
12.5-25.0	Suitable only under special condition very small basins reflowed
>25.	Unsuitable (too rapid) recommended for overhead method only

TABLE 4: Measured Steady State Infiltration Rates For Selected Soil Types

Soil type	Site	Steady state infiltration rate (cm/hour)
Well sand	1. M.Pudaiyur 2. Thatcher	8.40 19.2
Poor sand	3. Aalambadi 4. T.Enthal 5. Vagaiyur 6. Ramanatham 7. Edaicheruvai 8. Ivanur	21 15 20.4 15 13.2 13.2
Poor Clay	9. Cinnathukurichi 10. Kavanur 11. Karmangudi 12. Devangudi	16.8 7.2 10.8 18
Well Clay	13. Vasistapuram 14. Sevveri 15. Ogalur 16. Thirumandurai 17. Agaram Sigoor 18. Alichigudi 19. Deevalur 20. Vadagarai 21. Narasingamangalam 22. Kovilur 23. Nithinatham 24. Aathamangalam 25. Avinangudi 26. Eraiyur 27. Irulampattu 28. Karaiyur 29. TV.Puthur 30. Nemam	9.6 17.4 22.8 12 5.4 12 22.8 15.6 25.2 10.8 19.2 18 24 10.8 10.8 13.2 30 9.6

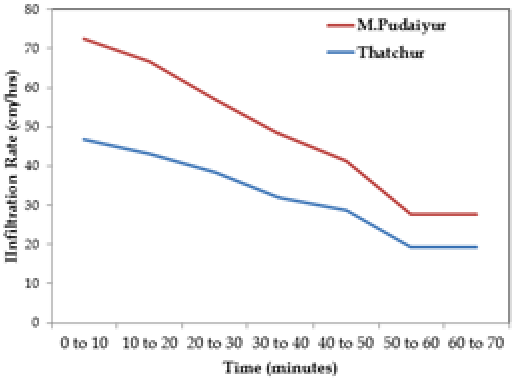

Figure 3: Infiltration curve for Well Sand

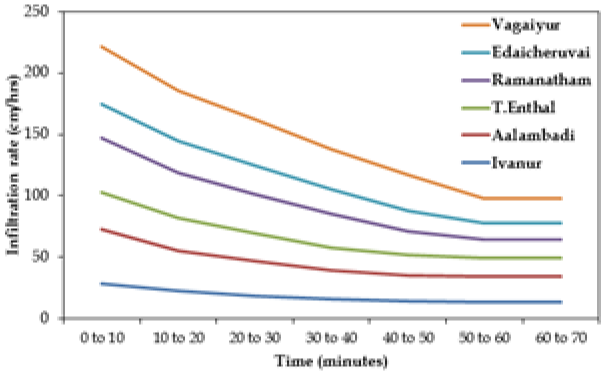

Figure 4: Infiltration curve for Poor Sand

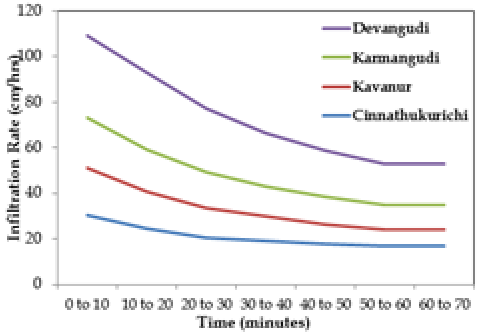

Figure 5: Infiltration curve for Poor Clay

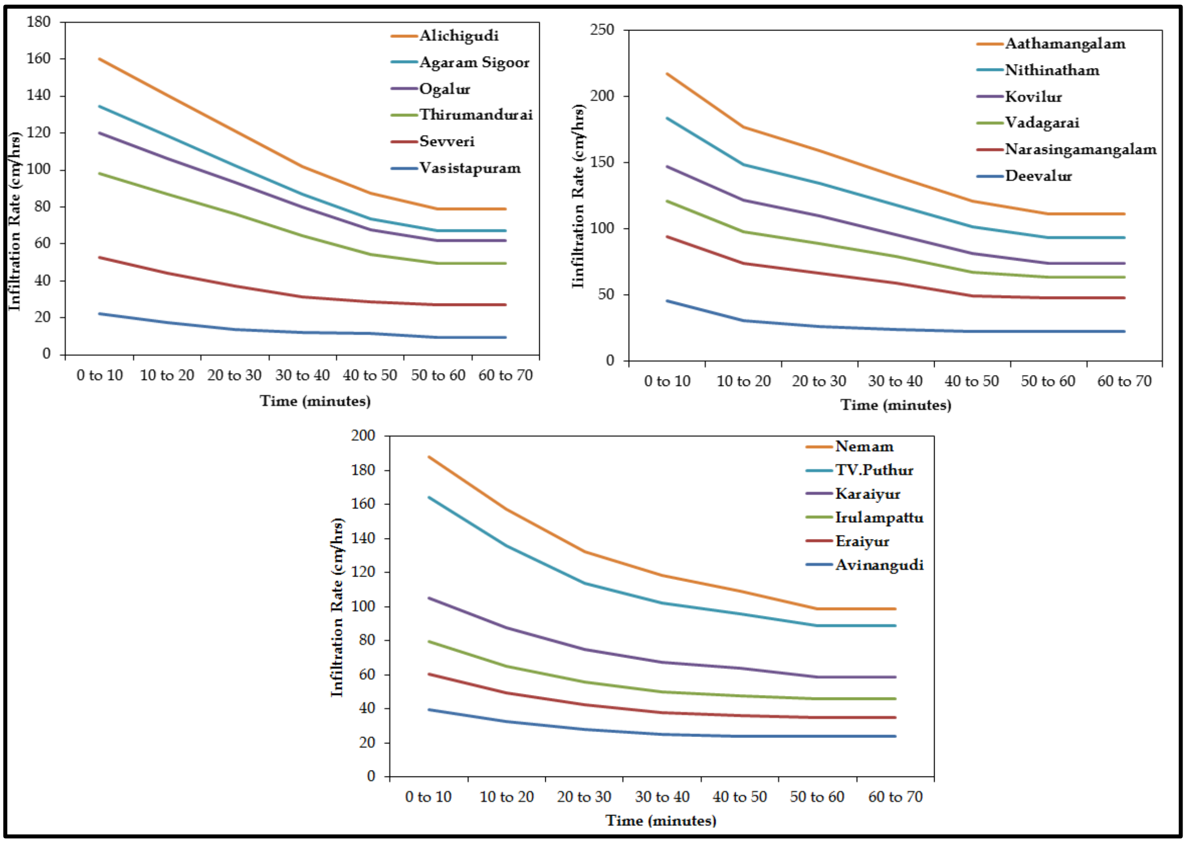

Figure 6: Infiltration rate curves for Well Clay

SOILS AND LANDUSE

The study area is broadly classified into 7 soil types. They are sandyclayloam, sandy clay, sandy loam, silt clay, sandloam, clay and sand. The soil groups are shown in (Fig.7). The main crops grown in the area are paddy and sugarcane. The entire northern part is covered by agriculture especially more than two crop. The broad landuse/cover distribution in the wellington reservoir is shown in (Fig.9).

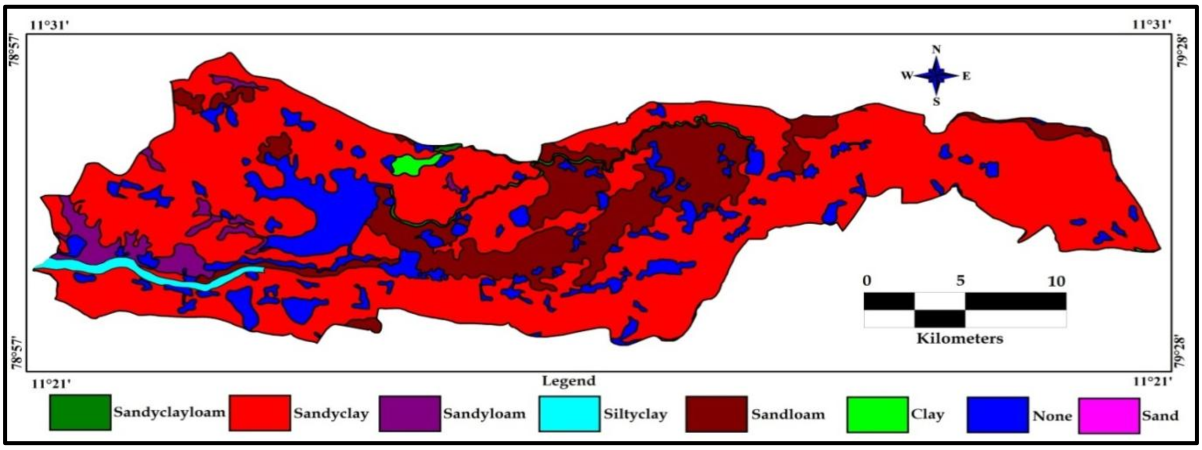

Fig: 7. Soil group map

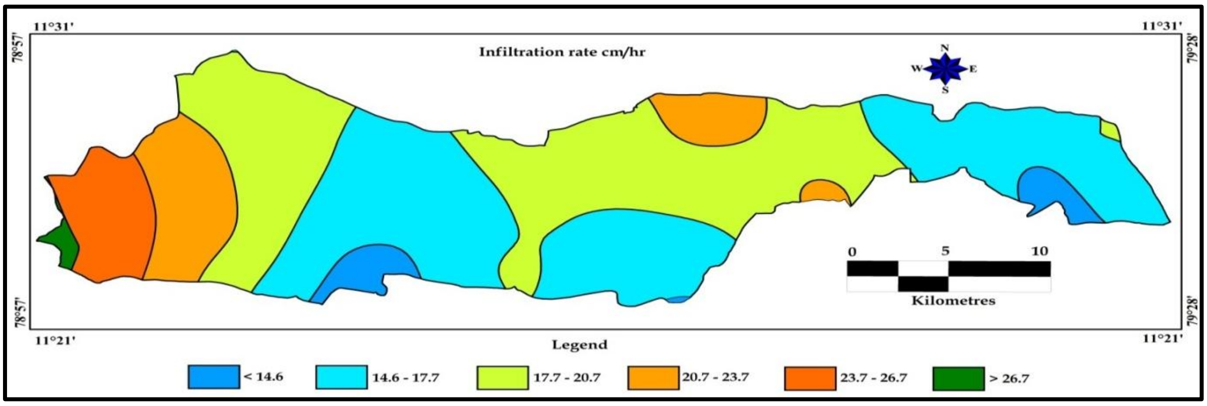

Fig: 8. Infiltration rate of the study area

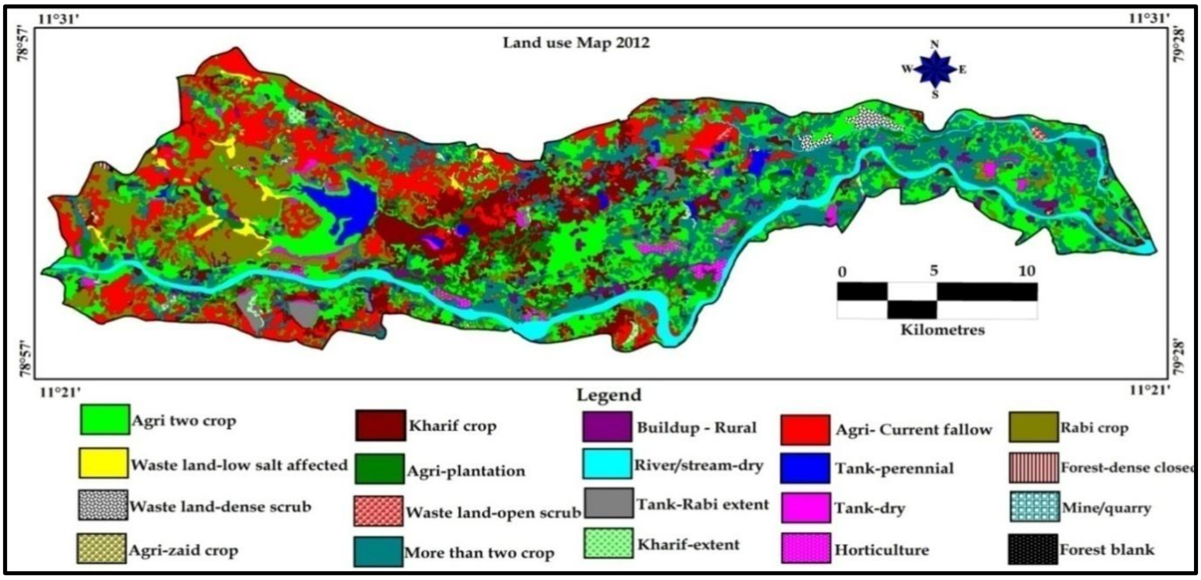

Fig: 9. Landuse/cover map of the Study area

IV. CONCLUSIONS

The current study determined steady state infiltration rates of different soil types in selected areas of Wellington reservoir in Tittagudi taluk, Cuddalore district, Tamilnadu. Well sand, poor sand, poor clay and well were identified and their steady state infiltration rates ranged from 8.4 – 19.2, 13.2 – 21, 7.2 - 18 and 5.4 – 30 cm/hour, respectively. Well sand soil has the highest initial and steady infiltration rates due to the fact that it has coarse texture and large porous spaces which promote fast infiltration. The measured infiltration rates were higher than the basic values which were attributed to local variations in soil structure. The infiltration rate curves determined are asymptotic and are adequately described by existing infiltration models such as [5]. The measured infiltration rates are significant in prediction of surface runoff, saturated hydraulic conductivity of surface layers and groundwater recharge, and developing or selecting efficient irrigation methods. Studies on infiltration rates of soils are required in solving many hydrological problems such as runoff estimation, soil moisture budgeting irrigation planning, landuse planning and management. This research shows that vegetation cover is one of the most important factors that accelerates infiltration rate and thus reduces overland flow which and ultimately in turns conserves the soil. The area is unsuitable for surface irrigation due to its high infiltration capacity. It is recommended that human activities in the form of deforestation, bush burning and grazing by livestock should be discouraged, while in this area; planting of trees on barren lands should be encouraged to reduce erosion.

V. ACKNOWLEDGMENT

The authors wish to thanks Dr.A.Murugappan, Professor and Head of Department of Civil Engineering, Annamalai University for providing necessary facilities for successful completion of this paper.

VI. AUTHOUR INDEX

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REFERENCES

[1]. A. Bhardwaj and R.Singh “Development of a portable rainfall simulator infiltrometer for infiltration, runoff and erosion studies,” *Agricultural Water Management*, 22, pp. 235–248, 1992.

[2]. P.K.Chhonkar, S.Bhadrary and T.J.Purakayastha, “Phytore-mediation of heavy metal contaminated soils,” *Monographs, Dehion of soil science & Agricultural chemistry*, IARI, New Delhi 2005.

[3]. J. Diamond, “Bulk Density Determination of Chlonroche Country Soil,” *Irish Geography*, (36) 2, 2004.

[4]. D. Hillel “Introduction to soil physics,” *Academic Press, San Diego*, CA, 1982.

[5]. R.E. Horton “An approach towards a physical interpretation of infiltration capacity,” *Soil Science Society of America*, Vol. 5, USA, 1940.

[6]. J.R.Landon “Booker tropical soil manual,” A handbook for soil survey and agricultural land evaluation in tropics and sub-tropics,” *Longman Science & Technology*, London, UK, ISBN: 0470205210, 474 pp. 1991.

[7]. M. Lili, V. F. Bralts, P.Yinghua, L.Han and L.Tingwu “Methods for measuring soil infiltration,” *State of the art, Int J Agric & Biol Eng.* 1(1), pp 22-30. (2008).

[8]. T. J. Marshall Soil Physics. Cambridge, *Cambridge University Press*. 2002.

[9]. Omkar and E Patwari “Infiltration studies in Jammu region,” *NIH, Roorkee report*, TR – 163. 1993.

[10]. G.E.Osuji, M.A.Okon, M.C.Chukwuma and I.I.Nwarie “Infiltration Characteristics of Soils under Selected Land Use Practices in Owerri, Southeastern Nigeria,” *Nwarie World Journal of Agricultural Sciences* 6 (3), pp 322-326, 2010.

[11]. R.K. Rattan, S. P.Datta, P.K. Chhonkar, K.Suribabu, and A. K. Sing “Long-term impact of irrigation with sewage effluents on heavy metal content in soils, crops and groundwater a case study,” *Agriculture, Ecosystems & Environment* 109, pp 310 – 322. 2005.

[12]. J.S.Rawat and S.P.Rai “Pattern and intensity of erosion in the environmentally stressed Khulgad watershed,” *Kumaun Himalaya*, *J. Geol. Soc. India*, 50, pp 331–338. 1997.

[13]. Rawat J S and Rawat M S 1994. “Accelerated erosion and denudation in the Nana Kosi watershed, central Himalaya, India,” *Part I: Sediment Load*; Mt. Res. Dev. 14 25–38.

[14]. J.S.Rawat, M.M.Haigh and M.S.Rawat “Hydrological response of a Himalayan pine forest micro-watershed,” Preliminary results; *Proc. Int. Symp on Hydrology of mountainous Areas*, Simla 28–30, pp 235–258. 1992.

[15]. J.S.Rawat, P.K.Purandara and S.Chandrakumar "Infiltration studies in the Malaprapa and Ghataprapa catchments," *NIH, Roorkee report*, CS – 105. 1993.

[16]. T.Shanley "Infiltration Rate Assessment of Soils Capacity to accept Rainfall,".2004.

[17]. R. Singh, N. Panigrahy and G .Philip "Modified rainfall simulator infiltrometer for infiltration, runoff and erosion studies," *Agricultural Water Management* 41, pp167–175. 1999.

[18]. K.L.Smedema, F.W.Voltman and W.D.Rycroft "Modern land drainage: Planning, design and management of agricultural drainage," *A.A. Balkema Publishers, Taylor and Francis*, the Netherlands, pp 446. 2004.

[19]. P.Soni and S.R.Singh "Average infiltration from cylinder infiltrometer test," *Indian Soc of Agri. Engineers*, 24th annual convection held at PKV, (Akols India). 1988.

[20]. P.Soni, S.Naithani and H.N.Matur "Infiltration studies under different vegetation cover," *Indian J of Forestery*, Vol 8(3), pp 170 – 173. 1985.

[21]. W.L.Thomas, G.S.Robert, R.T.Richard and W.N.Howard "Soil water monitoring and measurement," *A Pacific Northwest Publication*, Washington State University, Oregon, Idaho [online]. Available at http://cru.cahe.wsu.edu/CEPublications, 2004.

[22]. G.R, Senthilkumar, "Hydrogeological investigations in Tittagudi Taluk, Cuddalore, Tamil Nadu, S. India," *Unpublished thesis of Annamalai University*, pp. 23-27.2006.