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Study of Soil: An Important Consideration for Sustainable Settlement Development –In Context of Water Resources

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ABSTRACT: Water is an important constituent of all kinds of soils. It is held in the soil by adhesive forces between water molecules and organic and inorganic particles, and by cohesive forces between adjacent water molecules. Water retention is largely related to the organic matter and clay contents, whereas water movement is influenced by bulk density, porosity, and permeability. Water holding in soil depends on physical properties of soil as well as its hydrogeochemical characteristics. The amount of water held plays a vital link between the precipitation and water content of the soil. This paper is an attempt to correlate the soil and its water holding capacity depending upon its characteristics so as to use these properties as tool for sustainable settlement development.

Key words: Water, Soil characteristics, Physical and Chemical Properties, water holding capacity, Drainage.

I. INTRODUCTION

Properties that influence soil characteristics of holding water.

Soil properties: like its parent material, Topography, Climatic effects, the life form around it and time are the basics which are responsible for water holding capacity and soil relationships.

Soil Structure: The structure of soil like the porosity, size , shape and maturity affects the rate of response of soil to water percolation, saturation and holding capacity.

Soil Drainage: The drainage and run off of water from surface depends upon the slope, texture of soil, depth and rainfall.

All the above characteristics are studied to find out the relation between soil and water holding capacity.

Soil properties: Soil is basically made up of : **sand; silt; and clay particles.**

Every soil has a specific structure based upon its formation and parent material.

The structure of the soil affects pore space, size and distribution and therefore affects the rate of air and water movement. Well-developed structure soil allows favorable movement of air and water, while poor structure retards movement of air and water. Since plant roots move through the same channels in the soil as air and water, a porous structure supports air and water movement , resulting in increase in water penetration and water level.

Water enters more rapidly in a surface soil that has granular structure (particularly fine-textured soils) than one that has relatively little or small structure. For example Sandy soil have granular structure whereas clay soils have small structure. Silt too have porous structure to support the water movement.

Surface soil structure is usually granular, but such granules may be indistinct or completely absent if the soil is continuously tiled either for digging in construction activities or for roads , or if organic matter content is low. Subsoil with well developed blocky structure, is generally good for air and water movement in the soil. If platy structure is formed in the subsoil, downward water and air movement and root development in the soil will be slowed. Soil is disturbed or manipulated by human activity connected with construction and urbanization where one or more actions associated with urban activities: mixing, compaction, pulverization, filling, scraping, and/or the addition of synthetic contaminants or toxic substances at levels above those of natural soil disturb the natural behavior of the soil.

Distinct prismatic structure is often associated with subsoils that swell when wet and shrink when dry, resulting in reduced air and water movement. Very large and distinct subsoil prisms are also commonly associated with fragipan, which are massive and dense subsoil layers. Hence soil porosity enhances the water holding in hot and wet climates depending upon the characteristics of swelling/ Shrinking.

Soil porosity, or pore space, is the volume percentage of the total soil that is not occupied by solid particles.

Under field conditions, pore space is filled with a variable mix of water and air. If soil particles are packed closely together, as in graded surface soils or compact subsoils, total porosity is low and bulk density is high that results in blockage of movement and storage of water within the soil. If soil particles are arranged in porous aggregates, as is often the case in medium-textured soils and high in organic matter, the pore space per unit volume will be high and the bulk density will be correspondingly low which increases the water holding and water movement capacity of the soil.

The size of the individual pore spaces, rather than their combined volume, affects the air and water movement in soil. For eg; Pores smaller than about 0.05 mm (or finer than sand) in diameter are typically called *micro pores* and those larger than 0.05 mm are called *macro pores*. Macro pores allow the ready movement of air, roots, and percolating water. In contrast, micro pores in moist soils are typically filled with water, and this does not permit much air movement into or out of the soil. Internal water movement is also very slow in micro pores. Thus, the movement of air and water through a coarse-textured sandy soil can be surprisingly rapid despite its low total porosity because of the dominance of macrospores.

Porosity is indirectly related to hydraulic conductivity; for two similar sandy aquifers, the one with a higher porosity will typically have a higher hydraulic conductivity (more open area for the flow of water). Clays, which typically have very low hydraulic conductivity also have very high porosities (due to the structured nature of clay minerals), which means clay can hold a large volume of water per volume of bulk material, but does not release water rapidly.

Fine-textured clay soils, especially those without a stable granular structure, may have reduced movement of air and water even though they have a large volume of total pore space. In these fine-textured soils, micro pores are dominant. Since these small pores often stay full of water, aeration, especially in the subsoil, can be inadequate for root development and microbial activity.

The rate of water movement within and water holding capacity of the soil are very important relative to slope stability (Sidle et al., 1985, p. 42-45). These soil properties are affected by the size distributions of particles and the spaces between them, water input, slope gradient and shape, distance to water table, evapo transpiration and land use. Porosity can range from zero to more than 60%. Recently deposited sediments have higher porosity. Dense crystalline rock or highly compacted soft rocks such as shale have lower porosity.

Porosity. Presence of macro pores greatly increases the rate of water flow through the soil as shown in Fig. 1. Macro pore size decreases with depth in the soil, which in turn influences the depth at which lateral subsurface flow occurs in the soil. Such lateral flow may occur in the upper permeable organic layers or at the interface with bedrock or other impermeable surface where shear stress is the greatest, and result in reduced shear strength and a shallow landslide. A high water holding capacity may result in retention of water from previous storms, antecedent moisture levels, and thus lessen the amount of precipitation in a following storm needed to saturate the soil. Thus thin soils on slopes recharge quickly and may lead to debris slides.

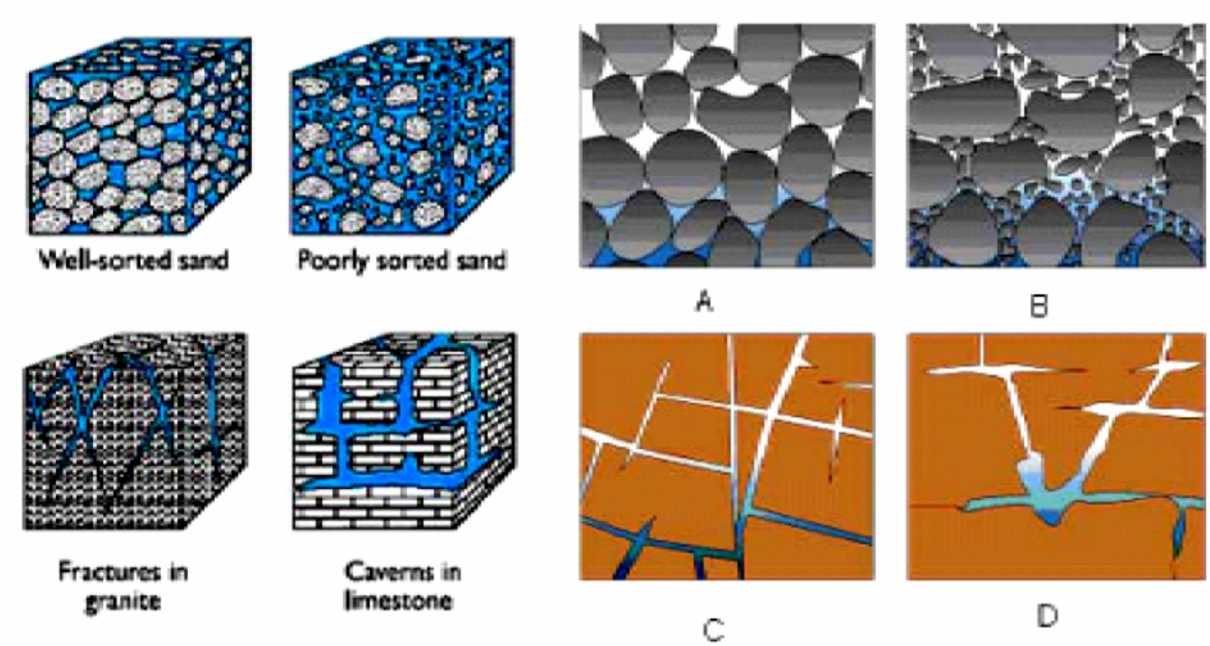

Figure B Relation between texture and porosity **A.** Well –sorted sand having high porosity; **B.** Poorly- sorted sand having low porosity; **C.** Fractured crystaline rocks (granite); **D.** Soluble rock-forming material (limestone).

Fig. 1.

Compaction reduces the total pore space and the mean pore size of the soil. Water holding capacity may be increased, but the movement of water through the soil is reduced as water moves slowly through small pores. In addition, the connections between bundles of pores may have been destroyed in the compaction process, and the water must follow a tortuous pathway to drain away (Rose, 1966).

Water-holding capacity is controlled primarily by soil texture and organic matter. Soils with smaller particles (silt and clay) have a larger surface area than those with larger sand particles, and a large surface area allows a soil to hold more water. A soil with a high percentage of silt and clay particles, which describes fine soil, has a higher water-holding capacity. The table illustrates water-holding-capacity differences as influenced by texture. Organic matter percentage also influences water-holding capacity. As the percentage increases, the water-holding capacity increases because of the affinity organic matter has for water.

Water availability is illustrated in the Fig. 2 by water levels in three different soil types. Excess or gravitational water drains quickly from the soil after a heavy rain because of gravitational forces (saturation point to field capacity). Plants may use small amounts of this water before it moves out of the root zone. Available water is retained in the soil after the excess has drained (field capacity to wilting point). This water is the most important for crop or forage production. Plants can use approximately 50 percent of it without exhibiting stress, but if less than 50 percent is available, drought stress can result. Unavailable water is soil moisture that is held so tightly by the soil that it cannot be extracted by the plant. Water remains in the soil even below plants' wilting point.

Characteristics of different soils at wilting point, saturation point and water holding capacity.

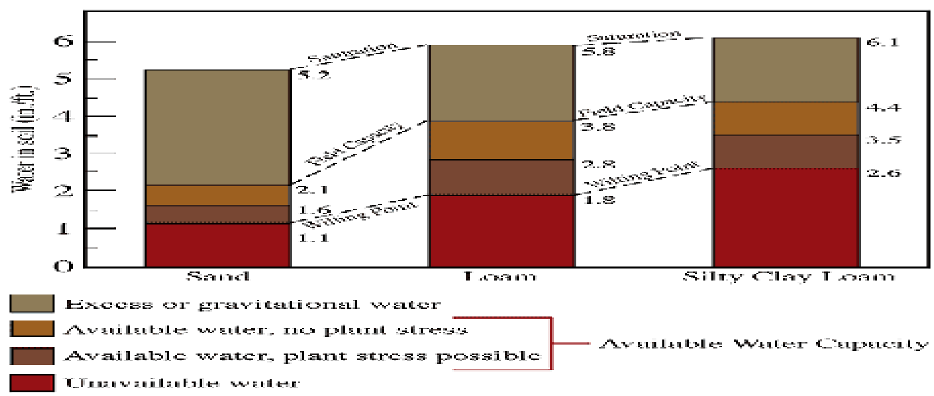

Fig. 2.

Hence, soil texture greatly influences water availability. The sandy soil can quickly be recharged with soil moisture but is unable to hold as much water as the soils with heavier textures. As texture becomes heavier, the wilting point increases because fine soils with narrow pore spacing hold water more tightly than soils with wide pore spacing.

Soil Drainage:

Important factors affecting soil drainage are:

A• slope.

B• depth to the water table.

C• texture of surface and subsoil layers, and of underlying materials.

D• soil structure.

E• problems caused by improper tillage, such as compacted subsoils or lack of surface soil structure.

In consideration to above points – points C-D-E get affected by development activities like excavation, digging, piping, building, pressurizing, dumping, water logging, runoff etc and hence natural system is hampered as soil losses its natural working characteristics and behaves as per changed situations that result in either more runoff, less recharge, more evaporation, less penetration etc.

The nature of soil drainage usually indicated by soil color patterns (such as mottles: **Mottling, soil**. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage.) and color variations with depth depict that soils become saturated with water for significant periods of time during the growing season, these oxidized (red/yellow) forms of iron are biochemically reduced to soluble forms and are moved with drainage waters. This creates a matrix of drab, dominantly gray colors. Subsoil zones with mixtures of bright red/yellow and gray mottling are indicative of seasonally fluctuating water tables, where the subsoil is wet during the winter/early spring and unsaturated in the summer/early fall. Poorly drained soils tend to accumulate large amounts of organic matter in their surface horizons because of limited oxidation and have very thick and dark A horizons. These type of changes are seen in Developed land either by urbanization or by blockage of natural drainage, which tends to accumulate water in some areas and create a runoff in other, resulting in imbalance to natural sub-soil conditions and working.

Drainage Class	Soil Characteristics	Effect on Cropping	Soil type
Excessively drained	Water is removed rapidly from soil.	Will probably require supplemental irrigation.	Sandy
Somewhat excessively drained			Sandy Silt
Well drained	Water is removed readily, but not rapidly.	No drainage required.	Sandy Clay
Moderately well drained	Water is removed somewhat slowly at some periods of the year.	May require supplemental drainage if crops that require good drainage are grown.	Clay (Porous)
Somewhat poorly drained	Water is removed so slowly that soil is wet at shallow depths periodically during the growing season.	Will probably require supplemental drainage for satisfactory use in production of most crops.	Clay
Poorly drained			Loamy
Very poorly drained	Free water is present at or near the surface during the growing season.		Loamy Clay

Hence, Clear, bright red and/or yellow subsoil colors indicate well-drained conditions where iron and other compounds are present in their oxidized forms. A soil is said to be well-drained when the solum (A+E+B horizon) exhibits strong red/yellow colors without any gray mottles.

Soils like clay that are wet in their upper 12 inches for considerable amount of time during growing season support the hydrophytic typical vegetation and are called Hydric Soils, which slows the downward moment of water through the soil causing the water to pond or perch.

To be identified as hydric, the soil should generally have one or more of the indicators. Hydric soil indicators are diagnostic horizons or other unique characteristics that are formed as a result of the hydric soil forming processes. There are hydric soils with morphologies that are difficult to interpret. These include soils with black, gray, or red parent material; soils with high pH; soils high or low in content of organic matter; recently developed hydric soils; and soils high in iron inputs.

Morphological features of hydric soils indicate that saturation and anaerobic conditions have existed under either contemporary or former hydrologic regimes. A dark surface horizon, underlain by a gray horizon is one common indicator. Another indicator of a hydric soil is a horizon that is predominantly gray with accumulations of red material (iron) along root channels or in masses. In the horizons with accumulated iron, there are also areas that are depleted, making them lighter than the main horizon color (NRCS, 1998).

	All Soils	Sandy Soils	Fine (Silty Clayey) soils	Remarks
Examples of indicators	Accumulated organic matter	Gray layer with red accumulations (gray layer); dark surface underlain by gray horizon)dark surface)	Gray Layer with or without red accumulations (gray layer); dark surface underlain by gray horizon (dark surface)	Silt with grey color and red accumulations help in water holding capacity.
Maximum Depth to Indicator(in)	Starting at surface	6 in (Gray layer) 4 in.(Dark Surface)	10 in.(Gray Colour) 6 in. (Dark surface)	Depth of water layer in clayey is more hence stores more.
Typical thickness of Indicators (in)	8”16”or greater than 16 inches	4 in (gray layer) 4 in.(dark surface)	6 in (gray layer) 6 in. (dark surface)	Clay soils has more capacity than sandy.

Physical principle: Water in soil or sediment near the ground surface normally evaporates during the day until the ground surface is heated. The evaporation is greatest in hot regions, and most severe in windy deserts. Depleted by evaporative loss, the pore space in soil or sediment would be completely filled by air if the evaporated water is not replaced by water from below. So it results that hot soils once get filled with air are not capable of penetrating more water and thus create run-offs to disperse water in other areas.

The amount of water in the soil is dependent upon two factors:

- First, soil water is intimately related to the climate, or the long term precipitation patterns, of an area.
- Secondly, the amount of water in the soil depends upon how much water a soil may hold.

Water holding capacity

Since water is held within the pores of the soil, the water holding capacity depends on capillary action and the size of the pores that exist between soil particles as shown in Figure 3&4. Sandy soils have large particles and large pores. However, large pores do not have a great ability to hold water. As a result, sandy soils drain excessively. On the other hand, clayey soils have small particles and small pores. Since small pores have a greater ability to hold water, clayey soils tend to have high water holding capacity.

The water-holding capacity of sand is low. This is due to large pore space between particles which allows water to drain readily from the soil. Soils with large amounts of sand possess good drainage and aeration, and are usually referred to as "light soils" or "coarse soil."

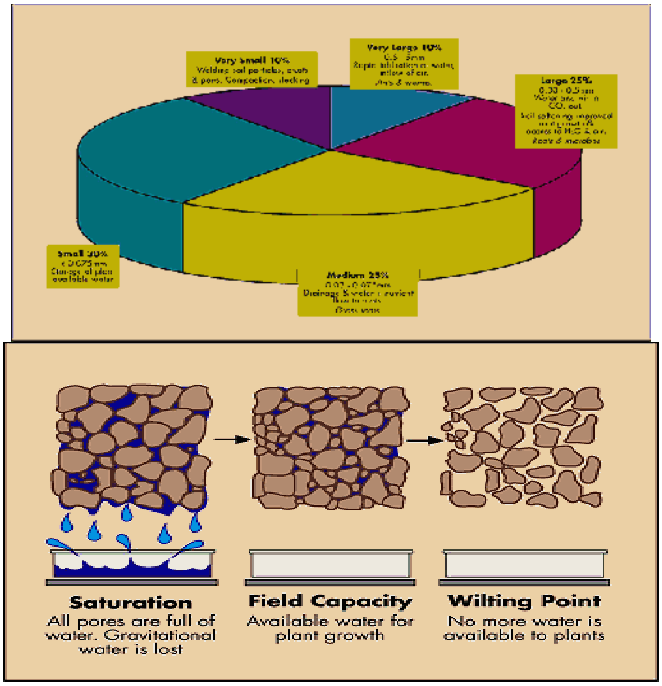

Fig. 3.

Water holding capacity (mm/cm depth of soil) of main texture groups. Figures are averages and vary with structure and organic matter differences.

Texture	Field Capacity	Wilting point	Available water
Coarse sand	0.6	0.2	0.4
Fine sand	1.0	0.4	0.6
Loamy sand	1.4	0.6	0.8
Sandy loam	2.0	0.8	1.2
Light sandy clay loam	2.3	1.0	1.3
Loam	2.7	1.2	1.5
Sandy clay loam	2.8	1.3	1.5
Clay loam	3.2	1.4	1.8
Clay	4.0	2.5	1.5
Self-mulching clay	4.5	2.5	2.0

Source: Department of Agriculture Bulletin 462, 1960

Fig. 4.

Water in the saturated zone, according to Darcy's Law, cannot rise under its hydrologic potential above the groundwater-table, because the groundwater table is defined by the surface of the greatest height to which underground water in a saturated zone will move. Water in the unsaturated zone above the groundwater table does not move according to Darcy's Law; water in the pore-space of porous medium in the unsaturated zone moves according to the law of capillary pressure.

The soil or sediment consisting clay or very fine silt, have the diameter of the pore between mineral grains very, very small; smaller than micrometers, or microns and hence the small connecting pores in soil or sediment act like tortuous capillary tubes.

The capillary force of the "tortuous capillary tubes" draw up the water from a depth beneath the groundwater table, like water being sucked into a capillary tube. The finer the sediment or soil particles, the smaller the capillary and the greater is the capillary pressure and the higher is water sucked up from beneath the groundwater table leading to apparent increase in water level in some places and sudden fall in some without capillary action.

Underground water is lost to the air by evaporation. Wet ground after a rain dries quickly because water in the pore space near the surface is easily evaporated. After the water is lost by evaporation, the near surface layer of sediment-particles in the unsaturated zone acts as a thermal insulator. Water is then sucked up by the capillary pressure into the unsaturated zone, where it is heated up and evaporated. Where there is little or no capillary pressure, water cannot move up toward the surface.

Thus the loss of water by evaporation is greater in clay and fine silt though they have very small pores and loss of water is reduces in surfaces with large pores as the pore space is filled with air insulating the layer.

This can be very beneficial to decide the type of land use to be proposed on surfaces with the mentioned properties.

Evapotranspiration: Transpiration by vegetation reduces soil water content (Sidle et al., 1985, p. 54). Trees transpire more than do understory shrubs or short ground vegetation due to their higher surface roughness (Sidle *et al*., 1985, p. 54-55). Vegetation types with deeper roots are able to transpire more water and dry the soil to greater depths.

Studies in many places have revealed the insulating effect of the unsaturated zone, and the effectiveness of various types of sediments as insulation to prevent evaporative loss. Experiments have shown that rate of water loss from sediment at a depth of a meter is reduced to a few percent of the rate of the water loss at surface. Where the unsaturated zone is a sand or gravel layer more than a meter thick, very little water is lost by evaporation, because the water in the sand or gravel below the groundwater table cannot be sucked up to replace the water evaporated in the unsaturated zone. The evaporative loss of water from the unsaturated zone of clay or mud sediment is much greater, the strong capillary force effectively sucks up water from the depth of the zone to replace water loss at surface by evaporation.

Publications like GIS Techniques for Groundwater contamination Risk Mapping by P. Sunil Raj Kiran, R. Santhosh Kumar, K. Stalin, P. Archana, l. Sridevi, A. Selva Radha , Improving soil Moisture, Agnote DPI – 494, August 2004**,** The State of NSW, NSW Department of Primary Industries 2004, **Water Management on** Turfgrasses, Richard L. Duble, Turfgrass Specialist Texas Cooperative Extension, The Potentialities for Decreasing Soil Moisture Evaporation Loss[1] E.R. Lemon[2,] reveal that evaporative loss from a water-bearing porous medium can be reduced to a minimum or eliminated if the medium is covered by an insulating layer of a certain thickness, commonly less than 1 meter thick, of debris which has no capillary ability to suck up water from below. In other words, water can be stored in a porous medium with 40% of the volume filled and be insulated by a layer of coarse sand or gravel.

Hence soils with high evaporation losses may be made to cover with insulating layers of different types by putting them to various land uses like gardens, Roads, Turf Grounds, Built ups , water ponds etc. these types of uses will be beneficial for better land uses and balance the evaporation loss with the water holded by soils beneath the ground.

Especially the urban areas of today need the thoughtful management of land uses to increase water holding capacity of soil , to reduce the rate of run-off and evaporation.

Structural properties of soils

Shear strength of the soil is dependent on the normal stress on the slip surface, cohesion of soil particles, and the internal angle of friction (Sidle et al., 1985, p. 45-46). The normal stress is affected by the weight or density of the soil, which increases with increased moisture content, the soil depth and slope gradient. Water infiltrating into the soil increases the weight of the soil and the water pressure within the soil pores and brings about unstable conditions. Soil cohesion is brought about by electromagnetic attraction between soil particles, cementing by organic and inorganic materials, and surface tension in unsaturated clay particles. Cohesion is limited by the point at which water content deforms the soil enough to cause rupture, the amount of water needed to cause the soil to flow. The internal angle of friction or degree of interlocking of soil particles and aggregates is dependent on the shape, size, and packing arrangement of the soil particles. Physical and chemical weathering of primary minerals, such as biotitic and pyroxenes, results in production of clay particles (Sidle et al., 1985, p. 46).

Hydrology: Overland flow is minimal in vegetated, undisturbed areas, and thus the major down slope flow is subsurface. The infiltration rate is greater than the down slope transmission rate, hence the excess is pulled by gravity into the deeper layers of the soil to form or add to the groundwater; soothe shear strength in this deeper layer of the soil drops. Tension cracks, soil pipes and macro pores in the soil also divert subsurface flow downward into the deeper soil layers. Increasing water flow into deeper layers brings water into potential failure zones and decreases slope stability.

Thus to obtain the Ground water recharge the rate of run-off should be minimum so that the soil gets ample time to infiltrate water and vegetation helps it. Similarly areas with cracks and joints in soil with no vegetation will tend for more Run-offs and less penetration that too quite below the normal ground water level. Hence such areas need efforts for minim sing runoff and cover of pervious layers.

Soil Type and water holding Capacity:

Igneous: In Igneous and metamorphic rocks porosity is usually low because the minerals tend to be inter grown, leaving little free space. Higher fractured igneous and metamorphic rocks, however, could have high porosity .

Sand: Sand doesn't hold many nutrients or water. Clay can hold a lot of nutrients, and some of its kinds can hold quite a bit of water, but the structure of clay doesn't let air and water move through it well. Most of the water in a clay soil is so tightly bound to the clay particles that plants can't get it loose. So water holding of clay may be considered less as compared to other soils with more porous structure.

Sandy soils: comprise of approximately 80 - 100% sand, 0 - 10% silt and 0 - 10% clay by volume. Sandy soils are light and typically very free draining, usually holding water very poorly due to very low organic content.

Loam soil: comprise of approximately 25 - 50% sand, 30 - 50% silt and 10 - 30% clay by volume. Loam soils are somewhat heavier than sandy soils, but also tend to be fairly free draining, due to typically low organic content.

Clay soil: are typically comprised of approximately 0 - 45% sand, 0 - 45% silt and 50 - 100% clay by volume.

Clay soils are not typically free draining, and water tends to take a long time to infiltrate. When wet, such soils tend to allow virtually all water to run-off.

Soil type is very important in not only how fast water is absorbed into soil, but also in water retention (how much is held in the soil as opposed to how fast it drains out).

Some soil takes up water very slowly, such as clay soils, and also hold it well (they do not drain well).

Some soil absorb water well, such as peat and sandy soils. Peat holds the water well (doesn't drain very fast because of the high organic content) whereas sandy soils do not hold water well, allowing it to drain out fairly quickly.

According to Tests carried out on Various Soils by AGVISE Laboraties for their water holding Capacity , it was found that different soil behave differently under natural conditions and when pressure is applied on them , which can be related to pressure due Urbanization caused on soils.

Water holding capacity of:

Clay - under pressure = 42.8% and without Pressure = 73.7%

Silt Loam- Under Pressure = 50.4% and without pressure = 71.9%

Loam- under pressure = 32.5% and without pressure = 85.1%

Loamy Sand- under pressure=17.2% and without pressure = 29.4%

This shows that performance of all soils are affected under pressure of urbanization. Clay and Silty loam are better responders to pressure and water holding capacity. Whereas loam and sand are greatly affected by urbanization. Hence land with more sand and loam are not suitable for development and clay with sand can be developed so that their natural working of water holding is not affected.

Soil behavioral changes in urban areas: Urbanization increases surface runoff, by creating more impervious surfaces such as pavement and buildings, that do not allow percolation of the water down through the soil to the aquifer. It is instead forced directly into streams or storm water runoff drains, where erosion and siltation can be major problems, even when flooding is not. Increased runoff reduces groundwater recharge, thus lowering the water table and making droughts worse, especially for farmers and others who depend on water wells.

When anthropogenic contaminants are dissolved or suspended in runoff, the human impact is expanded to create water pollution. This pollutant load reaches various water resources such as streams, rivers, lakes, estuaries and oceans with resultant water chemistry changing these water systems and their related ecosystems.

Several general characteristics of urban soils emerge. These are:

1. Great vertical and spatial variability: Urban soil profiles show abrupt changes from one layer to another depending upon the constructional history of the soil. If topsoil is scraped away and later backfilled, two distinct layers result.

2. Modified soil structure leading to compaction: The-natural process of structure formation and the operations to maintain it are lacking in urban soils. These conditions include: 1. Most urban soils have been disturbed or displaced, at least partially destroying structure and reducing pore space, especially macro pores. 2. Low organic matter content which disfavors aggregation. The aggregating effects of soil organism activity are also reduced. 3. Low frequency of structure-enhancing wet dry or freeze-thaw cycles.

4. Urban soils are subjected to surface traffic or other forces over a range of moisture conditions that contribute to compaction.

3. Presence of a surface crust on bare soil, usually water-repellent: A bare urban soil exhibits a pronounced tendency to form a crust on or within several centimeters of the surface. The most obvious one is foot and wheel traffic destroying vegetative cover and compacting the surface soil. The binding effect of roots is absent as is the surface protection provided by organic litter.

4. Modified soil reaction, usually elevated: Urban soils tend to have soil reaction (pH) values higher than their natural counterparts

5. Restricted aeration and water drainage: Covering the soil surface with impervious material like asphalt or concrete cuts off water infiltration and gaseous diffusion. These processes are therefore confined to the uncovered surface. Lateral movement of water and gaseous diffusion is limited, the more so in compacted soils.

6. Interrupted nutrient cycling and modified soil organism activity: Beneficial organic nutrient-containing
(Especially nitrogen, sulfur and phosphorus) leaves, litter, and animal remains are removed as wastes, or are produced in small quantities due to stressful conditions.
7. Presence of anthropoid materials and other contaminants: During urbanization and its renewal the landscape is reshaped, filled or cut. This modification of the topography creates made land. Made land is typified by containing a high percentage of anthropoid materials (solid waste) as masonry, wood and paper, glass, plastic, metal, asphalt and organic garbage. These materials become incidentally mixed in the soil profile and affect the physical, chemical and biological properties of the soil.
8. Modified soil temperature regimes: urban areas create a heat island compared to the surrounding countryside.
The soil characteristics are dramatically changed when they are put to man-made activities or any kind of development that hampers their natural working and results in various unnatural problems. The soils of better water holding quality when converted to cemented layer or silt and sand when changed to hard bed, affect the natural way of water penetration, movement and infiltration.
Hence our urban areas require management policies to mitigate these problems mentioned.

Urban Groundwater Problems And Management Requirements

Underlying Cause	**Resultant Problems Groundwater**	**Management Requirements**
1. Inadequately controlled groundwater abstraction	Over abstraction of good quality resources within city limits Over abstraction of good quality resource around city periphery (competition between urban supply and agricultural irrigation)	Reserve good, deeper groundwater for sensitive uses and encourage use of shallow, poor groundwater for no sensitive uses Reserve good groundwater for potable supply and substitute treated waste water or shallow, poor groundwater for irrigation
2. Excessive subsurface contaminant load	Contaminant of municipal water supply boreholes / well fieldsGeneral widespread contamination of groundwater	Define source protection zones for priority control of surface contaminant load Reduce contamination load in selective areas, especially where aquifer is highly vulnerable, by appropriate planning provisions or mitigation measures Plan waste water treatment / landfill disposal sites taking account of groundwater interests and impacts
3. Excess urban infiltration	Rising water table beneath city causing: Basement flooding Malfunction of on-site sanitation units Reversal of aquifer flow direct (with contamination of per urban well fields by polluted urban groundwater)	Reduce urban infiltration by: Control of mains leakage Reducing seepage from -site sanitation unit by mains sewerage installation Increase abstraction of shallow (pollu groundwater for non sensitive uses

Geomorphic features of Water holding and flow.
The geomorphic features like alluvial fans buried pediments, old stream channels and the deep-seated interconnected fractures are the indicators of subsurface water accumulation (Mukherjee and Das, 1989). These features are the natural recharge sites due to their high permeability and water holding capacity, moreover it is clear that higher the permeability lower the drainage density and higher the drainage density higher the surface run off so it has been observed that the terrain transmissibility is inversely proportionate to the square of drainage density (Omar, 1990).

Das and Kader (1996) observed that combined effect of drainage density (01.15-14.76 km/sq km), stream frequency (0.95-12.11), bifurcation ration (2-10) and granitic litho logy favors high surface runoff and low infiltration. So once the type soil is identified for its Drainage Density are observed as a tool for generating run off or stopping more run-off as desired by putting that land into suitable use like tree plantation, pervious pavements, slope, soil structure and impervious layers of Cement etc.

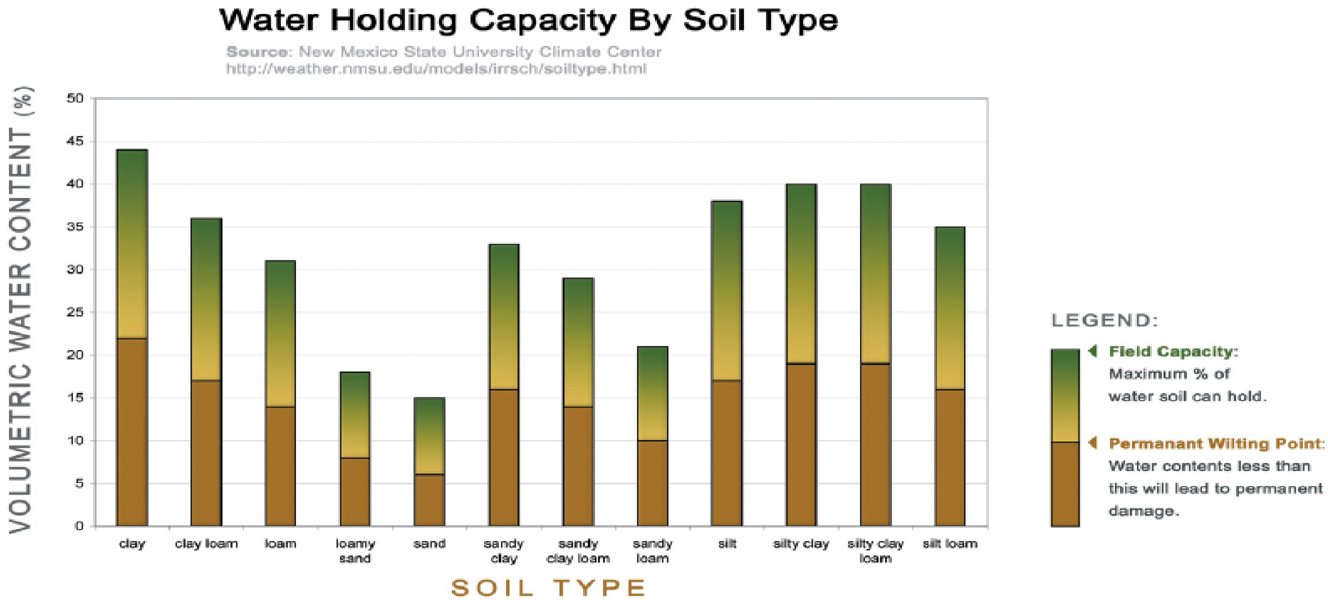

Fig. 5.

Physical Characteristics Affecting Runoff:

1. Land use has a significant effect on runoff from an area. For example, an area covered with parking lots will create much more runoff than a forested area. This is because the parking lots do not absorb any water, so almost all of the precipitation is turned immediately into surface runoff. Forests produce less runoff because the trees intercept some of the water, and some will be absorbed by the soil (abstraction).

We experience a developed area for example residential, commercial and industrial are main land uses in urban spaces. The percentage of Built up areas for various land uses lay as:

Residential : 50-60 %

Commercial: 15:20 %

Industrial: 2 -5%

Roads and Parks: 20-25%

Other uses: 15-20 %

Hence an urban area consist of maximum residential use along with Commercial , Road and Park areas which adds to the concrete cover over the natural soil. The soil beneath these land uses is affected and hence their planning needs a careful attention.

2. **Vegetation and soil type** influence runoff. Different types of vegetation and soils will limit the amount of precipitation that eventually turns into runoff. Sandy soils absorb more precipitation than soils composed of clay. Soils that have been in grass for long periods usually have a relatively high percentage of organic matter in their surface. Soils that develop under trees usually have a low organic matter percentage in the surface mineral soil, but do contain a surface litter layer (O horizon). Organic matter levels are typically higher in a topsoil supporting hay, pasture, or forest than in a topsoil used for cultivated crops. Soil organic matter is usually higher in poorly-drained soils because of limited oxidation, which slows down the overall biological decomposition process. The type and density of the vegetation have an impact on water evaporation losses and its flow over the surface of the land.

i. Slow moving water has more time to infiltrate into the ground and to evaporate.

If there is more **drainage area**, there is more potential to generate runoff. But the larger a basin is, the better the chances are for runoff to be stored or lost back to the atmosphere through evaporation and evapotranspiration.

ii. **Basin shape, slope and topography** Steeper, narrower basins generate more water than flat, broad ones.

iii. **Elevation and direction of orientation** can impact how much precipitation a basin receives as higher elevations generate more runoff than those with less elevation. Also ground with higher elevations have lower ground water table and fluctuating water tables depending upon Darcy’s law, whereas flat elevations enjoy greater water level with uniform water distribution. Depending on the weather patterns for an area, differently oriented basins will receive different amounts of precipitation. Elevation also plays a key role in the amount, and type of precipitation a basin receives.

iv. **Drainage network patterns** determine how efficient a basin is at transporting the runoff created on it. Basins with lots of rivers and streams can pass large volumes of water relatively quickly, whereas basins with lots of swamps, marshes and lakes tend to collect and store the runoff within these water bodies reducing the amount of runoff leaving the basin. Both basin types may create the same total volume of runoff, however one may store it in the basin and the other may pass the runoff downstream.

CONCLUSION

Hence to decide a land use so that the natural working of the water system is not hampered the above mentioned few points should be considered like the soil porosity, contents of silt, clay, sand, their structure, permeability, vegetation cover, water holding capacity of individual characteristics before and after development, saturation points , slope, impervious layer percentage to pervious layer and recharge zones to check the working without hampering the natural runoff.

The above discussion reveals that clay is very good for water recharging if it not too compact. Sand is good for water holding if porosity is less to reduce air filling in upper layer, silt is not too good in water holding though it can create run-off and water penetration fast. Thus if we say that a soil is made up of these three components a study of behavior of these to water is crucial to decide the type of activity to be proposed on these and get the changes in accordance with the nature.

On considering any urban area with different types of land uses and the above behavior of soil to water holding it can be broadly concluded that the soils with better water holding capacity even under pressure can be proposed for construction/ development etc and soils with low permeability, high runoff characteristics should be proposed for open parks, playgrounds with turf grasses etc. thus a suitable combination of study of soil and suitable activity proposed on it will surely help our urban centre's to cope up with the natural system and make a sustainable development.

In Nut Shell:

Soil type	Water holding capacity(when pressure not applied)	Pressure on Soil	Colour/porosity	Allowable land use	Specific Conditions.
Clay	70-80%	60-70%	Red/ Grey	Residential	Low density
Loamy	80-90%	70-80%	Red.	Commercial	Parking, Pavements should be porous.
Loamy sand	30-40%	25-30%	Porous-red	Parks , openspaces	More Plantation, insulating layers.
Silt loam	70-75%	65-70%	Porous	Residential, Industrial	Minimum Evaporation, insulating surface of grass, pavements.
Silty clay loam	70-80%	60-70%	Red-grey semiporous.	Residential, Industrial, Roads, pavements.	Proper Drainage, water infiltration to ground not very deep.

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