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Application of Fractal Theory to Quantify Structure from Some Soil Orders in Fars Province

A. Karami[1]-R. Zara[2]- V.A. Jahandideh Mahjen Abadi[3]
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Introduction: Fractal geometry concepts have been widely applied as a useful tool to describe complex natural phenomena, in particular,for a better understanding of soil physical systems. However, limited information is available on the fractal characteristics of soil properties or soil aggregation. A soil aggregate is made of closely packed sand, silt, clayand organic particles building upsoil structure. Soil aggregation is a soil quality index integrating the chemical, physical, andbiological processes involved in the genesis of soil structure. Soil structure and its stability are important issuesfor many agronomic and environmental processes. Thus, quantitative description of soil structure is very important. Soil forming factors in different soils (various orders) and forms affect the soil structureformation. Characterizing aggregate size distribution for different soil orders using fractal theory is necessary for evaluating the impact of soil forming factors on soil structure and quantifying the relationship between fractal dimension and other important soil properties. Therefore, the aims of this research were quantifying the structure of different soil orders using fractal geometry, mean weight diameter of aggregates (MWD)and geometric mean diameter of aggregates (GMD). In addition, MWD and GMD indices and fractal parameters of soil aggregate size distribution were compared toevaluate soil structure and determinethe relationship between fractal parameters with MWD, GMDand other soil properties.

Materials and Methods: Fractal models which simulate soil structure are also used to better understand soil behaviors. Aggregate size distribution is determined by sieving a fixed amount of soil mass under mechanical stress and is commonly synthesized by the MWD, GMDand fractal dimensions such as the fragmentation fractal dimensions. Therefore, aggregate size distribution and its stability variation were evaluated using some fractal models and MWD and GMD (empirically indices).In the current study, the original data were obtained from analysis of diagnostic horizons of seven important soil orderslocated in Fars Province in the Southern Iran. Soil samples were collected from diagnostic horizons of seven soil orders includingEntisols, Vertisols, Aridisols, Mollisols, Alfisols, Histosols and Inceptisols. The measured physico-chemical properties of soil were aggregate size distribution, soil particle size percentage (sand, silt, and clay), saturation percentage (SP), organic carbon (OC), pH, calcium carbonate equivalent (TNV), gypsum content, soil electrical conductivity (EC) and soil bulk density (BD). The MWD and GMD indices, the fractal dimensions and fractal parameters of aggregates were then calculated. Relationships between soil properties with MWD, GMD and the fractal dimension were also determined.

Results and Discussion: The results showed that there was a significant correlation between fractal dimension of Riue and Sposito and Taylor and Wheatcraft models and soil aggregate stability indices (MWD and GMD indices of aggregates) with the other soil characteristics. This correlation between fractal parameters with organic matter, bulk density, clay and sand percentage was stronger than other soil properties. There was a significant and negative correlation ($p< 0.01$) between fractal dimension of Riue and Sposito and Taylor and Wheatcraft models with mean weight diameter of aggregates and geometric mean diameter of aggregates. Inverse correlation between fractal dimension and aggregate stability indices illustrateed thatlower fractal dimensionswere calculated for the soils with more stable aggregates which have the highest mean weight diameter of aggregates and geometric mean diameter of aggregates. Subsequently, the fractal dimension of aggregates could reflect the aggregate stability factors. The values of coefficient of determination (R^2) and mean error (ME), root mean square error (RMSE), residual some of squares (RSS), mean square of non-fitted (Sr^2) and Akaike (AIC) statistical criteria indicated that Taylor and Wheatcraft model had the better performance. Although largerfractal dimensions were estimated by Riue and Sposito modelwhich can be explained by the

1 - Assistant Professor of Soil and Water Research Department, Fars Agricultural and Natural Resources Research and Education Center, AREEO, Shiraz, Iran
(* - Corresponding Auther Email:ad.karami@areeo.ac.ir)
2 - M.Sc. Graduated, Department of Soil Science, Fars Science and Research Branch, Islamic Azad University, Shiraz, Iran
3 - Ph. D. Student, Department of Soil Science, Faculty of Agriculture, Shiraz University, Shiraz, Iran

great model sensitivity, this model overall performed well.

Conclusion: The results indicated that fractal theory can be used to characterize soil structure at different soil orders and fractal dimensions of soil aggregate seems to be more effective in this regard, except forHistosols. Fractal dimension can be estimated using some easily available soil properties. Fractal theory can be applied to characterize and quantify soil structure in different soil orders of Fars Province.

Keywords: Aggregates size distribution, Aggregates stability, Fractal models, Soil orders, Soil structure