### Effects of Soil and Water Conservation Measures on Selected Physico-Chemical Soil Properties in Qenshiben Watershed Southern Ethiopia

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# ABSTRACT

Soil erosion is among the principal causes of declining soil resources in Ethiopia, which in turn successively affects agricultural productivity. To limit the trouble of soil erosion, for the last ten years soil and water conservation measures had been implemented in numerous parts of the country via community mass mobilization. Though, the soil and water conservation measures had been implemented, there was no consent among studies conducted on the effects of physicochemical soil properties in different parts of the country. The present study investigated the effects of soil and water conservation measures on physicochemical soil properties within the Qenshiben watershed. Each composite and core soil samples were taken from gentle, medium, and steep slope categories having conserved and adjacent non-conserved cultivated lands. Elite physicochemical soil properties had been analyzed using standard soil laboratory procedures. Results of the study revealed that almost all of the chosen physicochemical soil properties had been statistically significantly (p ≤ 0.05) affected by soil and water conservationmeasures. Significantly, better mean values of clay fraction (48.4%), total porosity (54%), soil reaction (5.5), soil organic carbon (2.64%), total nitrogen (0.22%) and Cation exchange capacity (28.14 cmolc/kg) were found beneath conserved than non-conserved lands having 42.3%, 47%, 5.1, 1.78%, 0.16% and 21.5 cmolc/kg respectively. Additionally, the result indicated that basic exchangeable K+, Mg2+ and Ca2+ cations were significantly better beneath conserved than non-conserved lands. Sand fraction, soil moisture content, available phosphorus, and exchangeable Na+ were not statistically significantly (p ≤ 0.05) affected by soil and water conservation measures. Generally, the study determined that soil and water conservation measures have important implications for improving physicochemical soil properties within the Qenshiben watershed. However, soil and water conservation measures have affected soil properties, there was a lower improvement in the status of elite physicochemical soil properties within the studied watershed. Therefore, integrated use of biological and physical soil and water conservation interventions and continuous follow-up of implemented structures would have paramount importance in raising physicochemical soil properties within the Qenshiben watershed.

**Key words:** Physicochemical Soil Properties, Qenshiben Watershed, Soil and Water Conservation Measures

# INTRODUCTION

Land degradation and its related decline in the productivity potential of agricultural land are challenging the economic and social well-being of the current and future generations on earth (Haregeweyn et al. 2012). Soil erosion is the main cause of land degradation and a leading factor contributing to poor agricultural development in developing countries (Gemechu, 2016). Cultivation of marginal lands, forest degradation for farming, and overgrazing are the major causes of increasing vulnerability of agricultural land to soil erosion in Ethiopia (Adimassu et al. 2014). The slope steepness, long cultivation history with outdated technology, and overgrazing make soil erosion more severe in Ethiopia (Nyssen et al. 2004). It has been identified as a major threat to the national economy (Hurni, 1993) and among the main challenges influencing the sustainability of agriculture (Hurni et al. 2015; Molla; Sisheber, 2017). As part of the Ethiopian highlands, the Upper Blue Nile Basin experiences high soil erosion rate (0–200 tons ha-1 year-1) (Haregeweyn et al. 2017) and 131 million tons of soil loss annually because of poor land use management systems (Betrie et al. 2011).

To resolve the trouble of soil erosion, soil and water conservation (SWC) practice was initiated in Ethiopia during the 1970s and 1980s. The main intent of the initiatives was to minimize erosion, restore soil fertility, rehabilitate degraded land, and increase agricultural productivity (Adimassu et al. 2014). Since, 2012 the country has developed community-based watershed development guideline, in which the participation of community gets due consideration for sustainable watershed development and management approach. Significant effort is occurring to replicate community based participatory integrated watershed management activities in the most of the regions. As a component of this effort, in the last ten years a nationwide 30 days public work campaign for watershed management has been started (Haregeweyn et al. 2012). Following the launch of the program, the regional bureaus of agriculture, district and zone agricultural offices were mobilized the farmers to help with the construction of SWC measures. Farmers massively and voluntarily implemented soil and water conservation measures on the farm lands at several watersheds.

However, the SWC measures are able to reduce soil erosion and affect soil properties; they are not equally effective in several parts of the country, also there is no consent on their effectiveness among different research findings reported in Ethiopia (Haregeweyn et al. 2015; Tilahun, 2019). Additionally, within the study area on the far side presenting an observation and analysis report of implemented SWC measures in terms of area coverage, no extra significant study was turned into performed on the effect on soil properties. Since, the current watershed management approach is campaign-based, evaluating its effect on soil properties would be vital for boosting and enhancing the SWC attempt. Therefore, the study was carried out to investigate the effects of SWC measures on elite physicochemical soil properties within Qenshiben watershed.

# MATERIALS AND METHOD

## 2.1 Description of the Study Area

The study was conducted within Qenshiben watershed (Figure 1) situated at Alicho Wuriro District, Silte Zone administration found in Southern Nations, Nationalities and People's Regional State (SNNPRS) of Ethiopia. Geographically, the watershed extends from 7º 51' 0"N - 8º 1' 0" N and 38º 7' 30" E - 38º 15' 0" E.  It is located 210 km south of Addis Ababa, which is that the capital town of Ethiopia and a 190 km away from Hawassa which is the capital city of SNNPRS.



Figure 1. Location map of the watershed

The annual precipitation of the study area ranges from 900 to 1120 mm and therefore the average annual precipitation of the watershed is 1010 mm. The watershed precipitation distribution is uni-modal rainfall with one long rainy season (April, May, Jun, July, August and September). The annual average minimum and maximum temperatures of the study area are 9.6 and 26.60C respectively. The watershed has tropical (Dega) and subtropical (Woina dega) agro ecologies, in which 80% of the watershed is dominated by highland tropical agro ecology (AWDANRMO, 2021).

The total area coverage of the watershed is 4496 hectares. The study watershed is characterized by undulating, rugged, and craggy topography with an altitude starting from 2400 to 3100 meter on top of sea level. In line with the Food and Agriculture Organization of the United Nations soil classification system, the soil of the study watershed  is characterized by *Pellic Vertisols*and *Haplic Phaeozems* soil types. *Pellic Vertisols* is the dominant soil within the watershed, which covers 80% of the watershed and, *Haplic Phaeozems* soil type covers only 20% of the watershed (FAO, 2012).

Mixed plantation, cultivated and grass lands are the major land use land covers in the watershed. Mixed plantation is the dominant land use type, which covers 75%; while crop and grass lands cover solely 15 and 10% respectively. Subsistence agriculture, in the style of mixed crop and livestock system, is the main supply of resource within the watershed. The vital cereal crops of the watershed are maize (*Zea mays*), sorghum (*Sorghum bicolor*), barley (*Hordeum vulgare*), and wheat (*Triticum aestivum*). The vegetables mature are potato (*Solanum tuberosum L*.), cabbage (*B. oleracea var. capitata*), faba bean (*Vicia faba L*.), pea (*Arachis hypogea*), and haricot bean (*Phaseolus vulgaris*) (AWDANRMO, 2021).

## 2.2 Methods of Data Collection

### *2.2.1 Soil sampling*

To investigate the result of SWC measures on the elite physicochemical soil properties, soil samples had been collected from lands preserved with soil bunds constructed before six years and adjacent non-conserved plot of lands. Sites having preserved and non- preserved plots were known through reconnaissance survey. Soil samples had been collected employing a 15 cm depth auger and 294.375 cm3 core samplers at a depth of 0–30 cm. A total of eighteen composite and core soil samples had been collected from two treatments (conserved and non-conserved plots); three slope categories (gentle (3–8%), medium (9–15%) and steep (16–25%) and three replicates. In line with Margesin, the “X” sampling design was used to collect soils from four corners and center of a plot having 10 m x 10m size (Margesin, 2005). Within the case of the land preserved with SWC structure, the sampling plots refers to the area between the two successive soil bund structures while, in the case of the non-preserved land with graded soil bund structures, the sampling plots refer to the area under cultivation that is found between successive farm boundaries.

### *2.2.2 Soil laboratory analysis*

Composite soil samples were air-dried, grinned, and sieved to pass through a 2 mm sieve to make it ready for laboratory analysis. The soil laboratory analysis was done at Areka agricultural research center following standard soil laboratory analysis procedures. Soil particle size distribution (PSD) was analyzed by Bouyoucos hydrometer method (Bouyoucos, 1951). The soil bulk density was determined by core sampler method described in Black (Black, 1965). Total porosity was estimated from bulk density and particle density (assuming particle density of 2.65 g/cm3). Hence, total porosity (%) = 1 − bulk density /particle density ∗ (100). The soil moisture content (SMC %) was determined following the method described by (Hazelton and Murphy, 2007). Soil reaction (soil pH) was determined by a 1:2.5 soil: water ratio using a pH meter as described by (Van, 2002). The soil organic carbon (SOC) concentration was determined by using Walkley and Black rapid titration method as described by (Sakar and Haldar, 2005). Total nitrogen (TN) was determined by the modified Kjeldahl methods as modified by (Sakar and Haldar, 2005). The available phosphorus (avP) content was determined using Olsen extraction method as described by (Van, 2002). The CEC was determined by using ammonium acetate method (Sakar and Haldar, 2005). Ca2+ and Mg2+ basic exchangeable cations were determined by atomic absorption spectrophotometer; flame photometer method was used for determination of Na+ and K+ exchangeable bases.

## 2.3 Methods of Data Analysis

The analysis of variance (ANOVA) was wont to take a look at the variations in physicochemical soil properties due to SWC practices with following the general linear model (GLM) procedure at (p ≤ 0.05) level of significance. The least significance difference (LSD) test was used to separate significantly differing treatment means that when the main effects had been found significant at (p ≤ 0.05). Pearson’s correlation coeﬃcient was performed to look at all potential paired combinations between physicochemical soil properties to get a correlation coeﬃcient matrix. The SPSS version 20 was used to analyze the overall soil property parameters.

# RESULT AND DISCUSSION

## 3.1 The Effect of Soil and Water Conservation Measures on Soil Physical Properties

### *3.1.1 Soil particle size distribution (SPSD, %)*

The evaluation made the usage of statistical strategies discovered that, besides sand fraction, clay and silt fractions of the soil had been statistically signiﬁcantly (p≤0.05) affected by treatments. Considerably better clay fraction was found beneath conserved (48.4%) than adjacent non-conserved land (42.3%) with SWC measure.  The study also discovered that; the higher silt fraction of soil was found beneath non-conserved lands (29.2%) than the land conserved (24.4%) with SWC measures (Table 1). Higher soil erosion, removal of fine materials, clay contents, and organic matter might be attainable reasons for comparatively lower clay and better silt content in non-conserved lands. According to USDA soil textural categorifications delineate by (Osman, 2013), the soil textural class of the study watershed has been dominated by clay (Table 1). The result of this study is in lined with (Mengistu et al. 2016; Mengie et al. 2019), who determined better clay fraction in croplands beneath terraced than adjacent non-terraced croplands.

### *3.1.2 Soil bulk density (SBD, g/cm3)*

The bulk density of the soil turned into statistically significantly (p≤0.05) tormented by SWC measures. The decrease BD of the soil turned into determined in conserved lands (1.2 g/cm3) than adjacent non-conserved lands (1.4 g/cm3) with SWC measures (Table 1). The lower BD of soil found within the preserved lands might be higher clay fractions and total porousness found within conserved lands. According to (Landon, 2013) important degree score for tropical soils, the imply cost of soil bulk density of the examine watershed is dense. The end result of the present study is in lined with (Abay et al. 2016; Worku, 2017) who reported a signiﬁcant higher value of BD was found in non-conserved than conserved watersheds with soil and water conservation measures.

### *3.1.3 Total porosity (TP, %)*

The result of SWC measures on total porosity of the studied soils was statistically significantly (p≤0.05) varied following treatment. Significantly better imply cost of soil TP was found within conserved (54%) than non-conserved land (47%) with SWC measures (Table 1). The better TP found in conserved lands might be, the soils having conservation practices would have less erosion and more proportion of clay. The study is in coated with (Damte et al. 2020), who confirmed considerably higher total porousness of the soil was found within the conserved than non-conserved farm lands with soil and water conservation measures.

Table 1: The mean values of soil physical properties in conserved and non-conserved land

|  |  |
| --- | --- |
| Treatments |  Soil physical properties |
| Clay (%) | Silt (%) | Sand (%) | BD (g/cm3) | SMC (%) | TP (%) |
| CL | 48.4±1.64a | 24.34±0.85a | 27.28 ±1.01a  | 1.22±0.04a | 10.45±0.99a | 54±0.014a |
| NCL | 42.3±0.94b | 29.12±0.64b | 28.38 ±1.17a  | 1.4±0.03b | 8.22±0.87a | 47±0.013b |
| LSD (0.05) | 4.87 | 3.7 | 1.12 | 0.18 | 2.25 | 1.17 |

Note: Means within columns followed by the same letters are not signiﬁcantly diﬀerent at p≤0.05; CL, conserved land; NCL, non-conserved land; LSD, Least Significant Difference.

## 3.2 The Effect of Soil Water and Conservation Measures on Soil Chemical Properties

### *3.2.1 Soil reaction (pH)*

The soil’s reaction (pH) value of the studied watershed was statistically significantly (p≤0.05) affected by treatments. Significantly higher mean value of soil hydrogen ion concentration was found beneath conserved (5.5) than non-conserved lands (5.1) with SWC measures (Table 2). The better soil pH found within the conserved land could be the soils protected with conservation practice would retain the basic cations along with ﬁne fraction, raising the soil pH. The acidity level of the study watershed in general was rated as strongly acidic based on (Osman, 2013) acidity and alkalinity categories of soil pH. The acidity of the soil could be related with its humid nature of the area and high amount of rainfall. This is true that greater rainfall increases soil acidity, and humid areas are more acidic than arid and semi-arid areas. Correspondingly to this study, (Ademe et al. 2017; Sirna and Leta, 2020) conjointly reported significant variations of pH value for SWC practices and found higher pH value in areas with SWC practices than areas without SWC practice.

### *3.2.2 Soil organic carbon (SOC, %)*

The LSD check discovered that the SOC turned into statistically appreciably (p≤0.05) affected by treatments. Significantly better imply cost of SOC turned into determined in conserved lands (2.64%) than adjacent non-conserved (1.78%) lands with SWC measures (Table 2). The higher SOC found within conserved lands could be the lands with SWC measures that provide mechanical barriers to the runoﬀ water would have reduced the loss of ﬁne soil fractions and accumulated and maintained organic matter and organic carbon. While all-time low SOC could also be attributed to the loss within the sort of decaying leaves, stems, and roots from soil due to lack of physical barriers. Likewise, (Hishe et al. 2017; Sirna and Leta, 2020) reported signiﬁcantly lower SOC content beneath the farmland while not SWC than conserved cultivated lands. In line with (Landon, 2013) important level rating for tropical soils, the mean SOC contents of the Qenshiben watershed are rated as low (2–4%).

### *3.2.3 Total nitrogen (TN, %)*

The examine end result additionally confirmed, the total nitrogen of the soil was statistically significantly (p≤0.05) affected by SWC measures. Significantly better imply cost of TN of the soil turned into determined within conserved (0.22%) than adjacent non-conserved (0.16%) lands with SWC measures (Table 2). The better TN within the conserved lands probably due to the result of SWC practices in reducing runoﬀ and soil loss and enhancing proﬁle water storage would enhance crop growth and contribute to organic matter and nitrogen input in the soil. Harmoniously, (Dagnachew et al 2019; Damte et al. 2020), also reported signiﬁcantly higher TN in farmlands conserved with SWC measures as compared to the non-conserved land. In line with (Landon, 2013) important level rating for tropical soils, the mean TN of Qenshiben watershed is rated as medium (0.15%–0.3%).

### *3.2.4 Carbon to nitrogen ratio (C: N)*

In the examine watershed, the C: N ratio turned into statistically appreciably (p≤0.05) tormented by treatments (Table 2). Significantly, a better C: N ratio turned into determined with inside the conserved lands (11.83) than non-conserved lands (10.77) with SWC. The better C: N cost determined with inside the conserved lands because of better imply cost of SOC and TN determined with inside the conserved lands as in comparison to non-conserved lands. In distinction to the current finding, (Damte et al. 2020) was reported the C: N ratio of the soil wasn't considerably affected by SWC measures. According to Landon critical level rating for tropical soils the calculated C: N ratio of Qenshiben watershed is rated as optimum (Landon, 2013).

### *3.2.5 Cation exchange capacity (CEC, cmolc/kg)*

The CEC of the studied soil was statistically signiﬁcantly (p≤0.05) affected by SWC   measures. Significantly better imply CEC cost turned into determined in conserved lands (28.14cmolc/kg) than adjacent non-conserved land (21.5cmolc/kg) with SWC measures (Table 2). The better mean CEC of soils found within the conserved lands might be the presence of higher organic matter and clay contents in lands conserved with SWC measures. The study is in lined with (Mulugeta and Karl, 2010) who reported the mean distinction in CEC was higher in conserved plots than non-conserved plots. In line with (Landon, 2013) important level rating for tropical soils, the mean CEC of the soil in Qenshiben watershed is rated as high (21–30 cmolc/kg).

### *3.2.6 Exchangeable basic cations (Na+, K+, Mg2+ and Ca2+, cmolc/kg)*

The end result indicated that besides Na+, other basic exchangeable cations had been statistically appreciably (p≤0.05) affected by SWC measures. Considerably higher mean values of exchangeable K+, Mg2+ and Ca2+ basic cations had been determined within the conserved lands than adjacent non-conserved lands with SWC structures (Table 2). The better mean values of basic cations found in the conserved land might be the result of conservation structures in protective the leaching of basic cations by erosion. Beneath all SWC practices, the relative abundance of basic cations in the exchange advanced was Na+< K+< Mg2+< Ca2+ for both conserved and non-conserved soils. Exchangeable Ca2+ (11.7, 6.5 cmolc/kg); Mg2+ (9.36, 6.85 cmolc/kg) and K+ (0.22, 0.14 cmolc/kg) constitutes the highest and lowest proportion in conserved and non-conserved plots respectively. Correspondingly, (Mengie et al. 2019), who reported the higher basic exchangeable cations were found in the conserved lands than non-conserved lands with SWC measures. They confirmed high clay soils can hold more exchangeable cations than low clay containing soils.

Table 2: The mean values of soil chemical properties in conserved and non-conserved land

|  |  |
| --- | --- |
| Treatments |  Chemical soil properties |
| pH | SOC (%) | TN (%) | C: N | AP (ppm) | CEC (cmolc/kg) | Basic cations (cmolc/kg) |
| Na+ | K+ | Mg2+ | Ca2+ |
| CL | 5.5± 0.05a | 2.64±0.14a | 0.22±0.009a | 11.83±0.3a | 11.74±0.48a | 28.14±1.3a | 0.05±0.008a | 0.22±0.015a | 9.36±0.47a | 11.7±1.14a |
| NCL | 5.1±0.06b | 1.78±0.10b | 0.16±0.01b  | 10.77±0.44b | 11.45±0.23a | 21.5±0.37b | 0.06±0.004a | 0.14±0.0078b | 6.85±0.3b | 6.5±0.38b |
| LSD (0.05) | 0.36 | 0.85 | 0.05 | 1.12 | 0.3 | 6.65 | 0.012 | 0.07 | 2.51 | 2.2 |

Note: Means within columns followed by the same letters are not signiﬁcantly diﬀerent at p≤0.05; CL, conserved land; NCL, non-conserved land; LSD, Least Significant Difference.

### *3.2.7 The correlation between physicochemical soil properties*

The simple linear (Pearson) correlation results disclosed the strength and magnitude of relationship among physical and chemical soil properties (Table 3). The hydrogen ion concentration of the studied soil showed a robust positive important relationship with TN (0.76\*\*), TP (0.75\*\*), CEC (0.62\*\*), clay (0.61\*\*) and every one exchangeable base except sodium. The matrix more revealed a really strong positive significant relationship (0.93\*\*) between TN and SOC. Total nitrogen additionally confirmed a sturdy high quality enormous correlation (0.76\*\*, 0.55\*, 0.50\*, 0.55\*) with TP, CEC, exchangeable Ca2+, and K+ content respectively. The bulk density of soil showed strong negative important relationship with TP (−0.94\*\*), TN (−0.76\*\*), CEC (−0.75\*\*), and hydrogen ion concentration (−0.75\*\*) and have positive significant relation with silt fraction (0.70\*\*) of the soil.

Table 3: Correlation among soil properties

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | SMC | SBD | TP | Clay | Silt | Sand | pH | SOC | avP | TN | CN | CEC | Ca | Mg | K | Na |
| SMC |  1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| SBD | **-.58\*** |  1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| TP | **.55\*** | **-.94\*\*** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Clay | .77\*\* | -.62\*\* | **.64\*\*** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| Silt | -.73\*\* | .70\*\* | -.70\*\* | **-.80\*\*** | 1 |  |  |  |  |  |  |  |  |  |  |  |
| Sand | -.57\* | .33 | -.34 | -.66\*\* | .25 | 1 |  |  |  |  |  |  |  |  |  |  |
| pH | .61\*\* | -.75\*\* | .75\*\* | .61\*\* | - .66\*\* | -.38 | 1 |  |  |  |  |  |  |  |  |  |
| SOC | .53\* | -.72\*\* | .76\*\* | .60\*\* | -.77\*\* | -.32 | .63\*\* | 1 |  |  |  |  |  |  |  |  |
| avP | .37 | -.43 | .28 | .39 | -.28 | -.34 | .24 | .27 | 1 |  |  |  |  |  |  |  |
| TN | .68\*\* | -.76\*\* | .76\*\* | .67\*\* | -.85\*\* | -.29 | .76\*\* | **.93\*\*** | .34 | 1 |  |  |  |  |  |  |
| C:N | -.07 | -.28 | .36 | .11 | -.13 | -.25 | .04 | .58\* | -.02 | .25 | 1 |  |  |  |  |  |
| CEC | .31 | -.41 | .43 | .40 | -.55\* | -.18 | .61\*\* | .54\* | .23 | .55\* | .26 | 1 |  |  |  |  |
| Ca | .35 | -.33 | .37 | .41 | -.48\* | -.28 | .63\*\* | .48\* | .19 | .50\* | .23 | **.95\*\*** | 1 |  |  |  |
| Mg | .18 | -.38 | .41 | .36 | -.43 | -.16 | .59\* | .38 | .27 | .40 | .12 | .77\*\* | **.78\*\*** | 1 |  |  |
| K | .24 | -.38 | .34 | .32 | -.46 | -.29 | .42 | .70\*\* | .39 | .55\* | .58\* | .64\*\* | .62\*\* | **.57\*** | 1 |  |
| Na | -.42 | .36 | -.33 | -.55\* | .35 | .43 | -.30 | -.31 | -.29 | -.39 | .08 | -.05 | .02 | .06 | -.08 | 1 |

\*. Correlation is significant at the 0.05 level (2-tailed).

\*\*. Correlation is significant at the 0.01 level (2-tailed).

# CONCLUSION AND RECOMMENDATION

The study revealed almost all of physicochemical soil properties had been undoubtedly tormented by soil and water conservation measures implemented within the study watershed. Bulk density, total porosity, silt and clay fractions, soil pH, total nitrogen, soil organic carbon, cation exchange capacity and basic cations (K+, Mg2+, Ca2+) had been statistically significantly (p ≤ 0.05) affected by SWC measures. Sand fraction of soil, soil moisture content, available phosphorous and exchangeable Na+ ion had not been statistically significantly (p ≤ 0.05) affected by SWC measures. Generally, the SWC measures had shown positive impact on the soil conditions, measured by the elite physicochemical soil properties.

Though, most of physicochemical soil properties had been affected by soil and water conservation interventions, the improvement of soil fertility status was lower. Therefore, integral use physical and biological soil and water conservation interventions and continuous follow up of implemented structures would have paramount importance in raising the status of physicochemical soil properties.

**DECLARATIONS**

**Consent to participate**

Not applicable

**Consent for publication**

Not applicable

**Competing Interests**

I declare that the authors have no competing interests as defined by Springer, or other interests that might be perceived to influence the results and/or discussion reported in this paper.

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**Availability of data and materials**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Authors’ contributions**

DA- has made significant contribution started from proposal writing, data collection, data analysis and interpretation and the final manuscript preparation.

AT- has participated in advising, guiding and editing proposal and manuscript preparation process.

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