International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(2): 430-436

Received: 04-01-2020
Accepted: 06-02-2020

**Vandana Kumari**
Research Scholar, Division of soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi, India

**Dr. TJ Purakayastha**
Principal Scientist, Division of soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi, India

**Corresponding Author:**
**Vandana Kumari**
Research Scholar, Division of soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi, India

# Effect of protracted fertilization and manuring on changeable pools of soil organic matter in four different soil types with wheat-based cropping systems of India

**Vandana Kumari and Dr. TJ Purakayastha**

**DOI:** https://doi.org/10.22271/chemi.2020.v8.i2g.8804

**Abstract**
Long term effect of manuring and fertilization on the SOM fractions *e.g.* hot water extractable C (HWEOM-C) and hot water extractable N (HWEOM-N) pool of SOC were studied in four major soil groups of India. The soil samples were collected in the year 2015 to a depth of 0–15 cm and 15-30 cm from the fields of All India Coordinated Project (AICRP) on Integrated Farming System continuing since 1983. The treatments comprised of control, 100%NPK, 50%NPK+50%N–FYM, 50%NPK+50%N–CR and 50%NPK+50%N–GM and green manuring crops like *Sesbania* (*Sesbania aculeate* L. in Ludhiana), Green gram (*Vigna radiata* L. in Pantnagar), *Sunhemp* (*Crotalaria juncea* L. in Jabalpur), *Karanj* (*Pongamia pinnata* L. in Ranchi). The results indicated that Hot water extractable carbon (HWEOM-C I, II) was highest in 50%NPK+50%N-FYM in both the soil depths for Pantnagar (Mollisol), Jabalpur (Vertisol) and Ranchi (Alfisol) but in Ludhiana (Inceptisol), HWEOM-C I was highest in 50%NPK+50%N-FYM and HWEOM-C II in 50%NPK+50%N-GM in both the soil depths. Hot water extractable nitrogen (HWEOM-N) was highest in 50%NPK+50%N-GM for all soil orders in both the soil depths.

**Keywords:** Soil organic matter, soil organic carbon, labile pools, water extractable nitrogen, soil quality

## 1. Introduction

Soil organic matter (SOM) has been identified as a key factor in maintaining soil quality and crop production (Doran and Parkin, 1994) [9]. It contributes directly to plant and microbial growth through its influences on soil chemical, physical and biological properties (Reeves, 1997) [26]. It is likely that constant organic matter supply through manure or crop residue application favours high level of microbial activities and production of binding agent in the macro aggregates (Haynes, 2005) [13]. Soil organic carbon (SOC) pools including hot water-soluble organic C (HWOC), microbial biomass C (MBC), water-extractable organic C (WEOC), mineralizable organic C ($C_{min}$), potassium permanganate oxidizable organic C ($KMnO_4$-C), and the oxidizable fractions of decreasing oxidizability (easily-oxidizable, oxidizable, and weakly oxidizable) were investigated as sensitive parameters to the application of organic manure, rice CR, and inorganic fertilizer nitrogen (N) in an 11-year field experiment under rice-wheat system by Benbi *et al.* (2015) [3]. WEOC exhibited a relatively greater sensitivity to management than TOC, suggesting that it may be used as a sensitive indicator of management-induced changes in soil organic matter under rice-wheat system. Long-term applications of farmyard manure and rice CR resulted in build-up of labile pool of SOC, suggesting the need for continued application of organic amendments for permanence of the accrued C under the experimental conditions. WEOM is a natural part that records for a little segment on soil natural issue (SOM), furthermore, is made out of effortlessly degradable particles that speak to the fundamental C and vitality hotspot for the soil microbial network (Smolander and Kitunen, 2002; Kaiser and Kalbitz, 2012) [28,14]. WEOM is in this manner the most powerful and bioavailable division of the SOM (McDowell, 2003) [23] and usually considered as a marker of microbial movement (Gutiérrez-Girón *et al.*, 2015) [11]. Availability of N in soil is closely associated with both quality and quantity of SOC (Singh et al., 2007) [27]. Ghani *et al.* (2013) [10] have revealed that the HWEOM-C being a part of the labile SOM and its association with other labile portions of SOM, for example, microbial biomass-C, water dissolvable C, extractable sugars and mineralisable-N. Furthermore, it has been firmly identified with soil microbial biomass and small-scale conglomeration could in this manner be utilized as one of the soil quality markers in soil– plant biological systems.

Characterizing the carbon and nitrogen content of labile organic matter fractions could indicate changes of soil quality due to management practice more rapidly than measuring changes in the magnitude of the whole SOM pool (Ding *et al.*, 2006; Kanchikerimath and Singh, 2001) [7, 15]. It can be vulnerable to microbial degradation because of low chemical recalcitrance of its components, lack of physical protection inside soil aggregates (Krull *et al.*, 2003) [17]. Manure application, even once per year, constantly prompted higher augmentations in both SOC and microbial pools and the mixes of concoction manures with compost by and large indicated practically identical impacts in the long-term experiments (Nayak *et al*., 2012) [24]. Abrol *et al*. (2000) [1] have attributed the declining design in alter productivity of the rice-based cropping sequence in IGP to the declining C stock in soil.

The maintenance of SOM with special reference to SOM quality is therefore extremely important for supplying essential plant nutrients and enhancing soil quality (Ladha *et al*., 2003) [18]. Soil organic carbon quality can be defined as the ability of organic carbon to supply organic molecules and to release carbon dioxide through metabolic pathways, which implies that low quality organic carbon corresponds to organic carbon molecules that needed high number of enzymatic steps to release $CO_2$ (Wiaux *et al.*, 2013) [33]. In short-term, nutrient cycles, especially labile forms of SOM play an important role (Tisdall and Oades, 1982) [31] which indicate changes in soil quality due to management practices more rapidly than measuring changes in the magnitude of total SOC (Ding *et al*., 2006) [7]. Soil microbial biomass C and water-soluble C is considered to be important SOM quality parameters because of their faster recycling causing release of nutrients (Janzen *et al.*, 1992; Manna *et al.*, 2013) [13, 21]. Though many studies throughout the world were able to identify appropriate management practices which enhance soil quality (Andrews *et al.*, 2004; Bhaduri *et al*., 2014; Biswas *et al.*, 2017; Karlen *et al.*, 1994) [2, 4, 5, 16], there is a lack of scientific information on SOM quality-based management systems influencing crop productivity. Changes in soil management practices influence the amount, quality and turnover of soil organic matter (Tiessen and Stewart, 1983) [30].

With this background the All India Coordinated Research Project on Integrated Farming System located in Ludhiana (Inceptisol), Ranchi (Alfisol), Jabalpur (Vertisol) and Pantnagar (Mollisol) with rice-wheat cropping system and maize wheat cropping system at Ranchi (Alfisol) in 0-15 cm and 15-30 cm soil depth was used for this study with the hypothesis that long-term application of carbon and nutrients through either FYM, greenmanure or crop residues in combination with chemical fertilizer having distinct effects on the more labile fraction of SOM in soils with varying soil order, texture and climatic conditions for soils. The objective of present study was to determine the level of changeable soil parameters (i) Hot water extractable organic matter C and N (WEOM-C, WEOM-N) in four soil types of India as influenced by long-term management practices over thirty-two years period (1983–2015).

## 2. Materials and methods

### 2.1 Experimental site

All India Coordinated Research Project (AICRP) on Long-term Fertilizer Experiment (LTFE) was initiated in 1983 at the experimental farm located in Pantnagar (Mollisols), Ludhiana (Inceptisols), Jabalpur (Vertisols) and Ranchi (Alfisols) with rice-wheat cropping system for all the locations except Ranchi having maize-wheat cropping system in Integrated Farming System (IFS) coordinated by IIFSR, Modipuram, India was used for the present study. Initial characteristics of the soil has been shown in Table 1. Ludhiana is situated in Punjab and is located at 30º56′N, 75º52′E and 247 m above mean sea level (m.s.l.) The climate of Ludhiana is semi-arid subtropical with hot dry summers and cool winters. Average annual rainfall is 500 mm and potential evapotranspiration 1500 mm. Pantnagar is located at 29ºN, 79º5′E and 244 m above m.s.l. in the foot hills of Shivalik range of the Himalayas. Climatically, the area is sub-humid subtropical with hot humid summers and severe cold winters. Average annual rainfall is about 1350 mm. Jabalpur is situated in central Madhya Pradesh and is located at 23º90’N latitude, 79º58′E longitude and 411.8 m above m.s.l. Jabalpur lies in subtropical regions thus, it enjoys the features of dry and sub humid climate. Climatically, the area is sub-humid subtropical average annual rainfall is about 1350 mm. Ranchi is located at 23º30′N, 85º15′E and 120 m above m.s.l. This area has sub-humid climate with severe hot, dry summer and cool winter. Average annual rainfall is about 1450 mm.

**Table 1:** Initial characteristics of the experimental soils

| Properties | Ludhiana | Pantnagar | Jabalpur | Ranchi |
|---|---|---|---|---|
| Sand | 54.0 | 32.0 | 28.0 | 55.0 |
| Silt | 28.0 | 39.0 | 19.0 | 22.0 |
| Clay | 18.0 | 29.0 | 53.0 | 23.0 |
| Texture (USDA) | Sandy loam | Silty Clay loam | Clay | Sandy clay loam |
| pH (1:2.5) | 8.15 | 7.3 | 7.54 | 6.5 |
| EC ($dSm^{-1}$) | 0.32 | 0.35 | 0.48 | 0.10 |
| Organic C ($g\ kg^{-1}$) | 3.1 | 14.2 | 6.0 | 4.2 |
| Available N ($kg\ ha^{-1}$) | 143.0 | 280.0 | 238.0 | 255.0 |
| Available P ($kg\ ha^{-1}$) | 11.0 | 14.5 | 8.6 | 14.2 |
| Available K ($kg\ ha^{-1}$) | 101.0 | 120.0 | 287.0 | 195.0 |
| Soil classification (USDA) | Typic Ustochrept | Aquic Hapludoll | Typic Haplusterts | Typic Haplustalf |

### 2.2. Experimental design

The treatments represented different combinations of inorganic and organic sources of nutrients to rice and wheat. Recommended Fertilizer Dose of different crops in the selected sites has been shown in Table 2. In rice, the full recommended levels of N, P, and K and 50% of N were supplemented through FYM, (CR) crop residue (wheat CR in Ludhiana, Pantnagar and Jabalpur; paddy CR in Ranchi) and green manuring crops like *Sesbania* (*Sesbania aculeate* L. in Ludhiana), Green gram (*Vigna radiata* L. in Pantnagar), *Sunhemp* (*Crotalaria juncea* L. in Jabalpur), *Karanj* (*Pongamiapinnata* L. in Ranchi). Of the 12 treatments, five selected for the present study shown in Table 3.

**Table 2:** Recommended Fertilizer Dose of different crops in the selected sites

| Location/soil type | Cropping system | 100% recommended fertiliser dose (kg ha$^{-1}$) | | | |
|---|---|---|---|---|---|
| | | N | P | K | $ZnSO_4$‡ |
| Ludhiana (Inceptisol) | Rice (*Oryza sativa* L.), cv. PR-116 (Wet season) | 120 | 30 | 30 | 60 |
| | Wheat (*Triticum aestivum* L.), cv. PBW-343 (Winter season) | 120 | 60 | 30 | - |
| Pantnagar (Mollisol) | Rice (*Oryza sativa* L.), cv. PR-113 (Wet season) | 120 | 40 | - | - |
| | Wheat (*Triticum aestivum* L.), cv. PBW-343 (Winter season) | 120 | 40 | - | - |
| Jabalpur (Vertisol) | Rice (*Oryza sativa* L.), cv. MR-219 (Wet season) | 120 | 60 | 40 | |
| | Wheat (*Triticum aestivum* L.), cv. GW-273 (Winter season) | 120 | 60 | 40 | |
| Ranchi (Alfisol) | Maize (*Zea mays* L.), cv. M-9000(Wet season) | 100 | 22 | 21 | - |
| | Wheat (*Triticum aestivum* L.), cv. DCR-162 (Winter season) | 100 | 22 | 21 | - |

‡Applied to all plots once in every three years before rice crop.
¶ Phosphosrus treatment included since wet season of the year 2000.

**Table 3:** Season− wise treatment details

| | Wet season *(Kharif)* | Winter season *(Rabi)* |
|---|---|---|
| $T_1$ | No fertilizer, no organic manure(control) | No fertilizer, no organic manure (control) |
| $T_2$ | 100% rec. NPK dose through fertilizers | 100% rec. NPK dose through fertilizers |
| $T_3$ | 50% rec. NPK dose through fertilizers+ 50% N through FYM (farmyard manure) | 100% rec. NPK dose through fertilizers |
| $T_4$ | 50% rec. NPK dose through fertilizers+ 50 N through CR (CR) | 100% rec. NPK dose through fertilizes |
| $T_5$ | 50% rec. NPK dose through fertilizers+ 50% N through GM (green manure) | 100% rec. NPK dose through fertilizers |

### 2.3. Soil sampling
Soil samples were collected to a depth of 0−15 cm and 15-30 cm from the respective plots with the help of core sampler in the year 2015. Samples were obtained after removing plant debris from the soil surface. Immediately after collection, the soil samples were brought to the laboratory; air dried, ground, and passed through a 2-mm sieve for estimation of HWEOM-C and HWEOM-N. The moisture content in soil samples was determined after drying the soil at 105 °C in an oven for 24 h. Soil bulk density was calculated from weights of total field moist soil, an oven-dried (105 °C, 24 h) sub-sample and the volume of the core sampler following the method of Veihmeyer and Hendrickson (1948) [32].

### 2.4. Soil organic matter (SOM) pools
#### 2.4.1. Hot water extractable organic matter C (HWEOM-C)
The extraction of HWEOM-C was determined following the procedure of Ghani *et al*. (2003) [9] in two simple steps. The first step involved removal of readily soluble C (HWEOM-C I) from the soils that may have come from organic manures and soluble plant residues. The second step involved extraction of labile components of soil carbon at 80 °C for 16 h. This is subsequently referred to as hot-water extractable carbon (HWEOM-C II). Soil samples (equivalent 3 g oven dry weight) were weighed into 50 ml polypropylene centrifuge tubes. These were extracted with 30 ml of distilled water for30 min on an end-over-end shaker at 30 rpm and at 20 $^0$C, centrifuged for 20 min at 3500 rpm and all the supernatant from was filtered through 0.45 mm cellulose nitrate membrane filter into separate vials for carbon analysis. A further 30 ml of distilled water was added to the sediments in the same tubes. These tubes were shaken on a vortex shaker for 10 s to suspend the soil in the water. The tubes were capped and left for 16 h in a hot-water bath at 80 $^0$C. At the end of the extraction period, each tube was shaken for 10 s on a vortex shaker to ensure that HWEOM-C released from the SOM was fully suspended in the extraction medium. These tubes were then centrifuged for 20 min at 3500 rpm. The supernatants were filtered through 0.45 mm cellulose nitrate membrane filters. Total carbon content in both the first and second extracts was determined by (Snyder and Trofymow, 1984) [29] digestion and diffusion/distillation method.

#### 2.4.2. Hot water extractable organic matter N (WEOM-N)
It was extracted according to Ghani *et al*. (2003) [9]. In brief, 3g of dry soil was extracted with 30 ml ultra-pure water in a centrifuge tube. The second step involved extraction at 80 °C for 16 h referred to as hot-water extractable nitrogen (HWEOM-N). The HWEOM-N was determined by drying the supernatant in an oven at 60 ºC followed by digestion with concentrated $H_2SO_4$ and digestion mixture ($^{K2SO4}$:$CuSO_4$: Se powder − 200:20:1) in a Kjeltech digestion assembly (Pelican make, Kelplus, model) at 390 ºC until the mixture was clear followed by distillation and absorbing the distillate in boric acid mixed indicator in Kjeltech distillation assembly (Pelican make, Kelplus model) followed by titration with standard $H_2SO_4$.

## 3. Results
### 3.1. Hot water extractable organic matter C and N (HWEOM-C I, HWEOM-C II and HWEOM-N)
In the soils of Ludhiana, it was observed that the HWEOM-C I in 0-15 cm soil samples showed significant variations among the treatments (Table 4). The HWEOM-C I was highest (0.127 mg g$^{-1}$ and 0.12 mg g$^{-1}$) in T3 (50%NPK+50%N-FYM) and T5 treatment (50%NPK+50%N-GM), respectively followed by T2 (100% NPK) and T4 (50%NPK+50%N-CR). The HWEOM-C II was highest (0.23 mg g$^{-1}$, 0.22 mg g$^{-1}$ and 0.20 mg g$^{-1}$) in T5 treatment (50%NPK+50%N-GM). HWEOM-N varied significantly in 0-15 cm soil samples among the treatments (Table 4). Increase of HWEOM-N in T5 and T3 were 3.79 and 3.15 times over T1 (control) respectively. The treatment

T4 (50%NPK+50%N-CR) and T2 (100%NPK) showed 2.35 and 1.78 times increase in WEOM-N over control.
In 15-30 cm, HWEOM-C I was highest (0.127 mg $g^{-1}$ and 0.12 mg $g^{-1}$) in T3 (50%NPK+50%N-FYM) and T5 treatment (50%NPK+50%N-GM), respectively. T2 (100%NPK) and T4 (50%NPK+50%N-CR) were at par with respect to HWEOM-C I. The HWEOM-C II was highest in T5 treatment (50%NPK+50%N-GM) and T3 (50%NPK+50%N-FYM) which were at par followed by T4 (50%NPK+50%N-CR) and T2 (100% NPK), respectively. The increase of HWEOM-N in T5 and T3 were 4.5 and 3.8 times over T1 (control) respectively. The treatment T4 (50%NPK+50%N-CR) and T2 (100%NPK) showed 2.66 and 2.16 times increase in HWEOM-N over T1.

**Table 4:** Long term effect of manuring and fertilization on hot water extractable C and N (HWEOM-C I, II and N) (in mg $g^{-1}$) in 0-15 cm and 15-30 cm soils of Ludhiana.

| Treatments | HWEOM-N | HWEOM-C I | HWEOM-C II | HWEOM-N | HWEOM-C I | HWEOM-C II |
|---|---|---|---|---|---|---|
| | | 0-15 cm | | | 15-30 cm | |
| T1-Control | 0.015e | 0.030c | 0.047c | 0.117e | 0.033c | 0.040d |
| T2-100%NPK | 0.026d | 0.077b | 0.123b | 0.026d | 0.070b | 0.087c |
| T3-50%NPK+50%N- FYM | 0.036c | 0.127a | 0.223a | 0.043b | 0.127a | 0.183a |
| T4-50%NPK+ 50% N-CR | 0.048b | 0.067b | 0.200a | 0.032c | 0.053c | 0.143b |
| T5-50%NPK+ 50% N-GM | 0.058a | 0.120a | 0.230a | 0.054a | 0.120a | 0.186a |

§The data followed by different lowercase letters are significant according to Duncan's Multiple Range (DMRT) Test at 5% level of significance. Values in the same column followed by different lowercase letters (a–e) are significantly different at P=0.05 according to Duncan's Multiple Range Test.

In the soils of Pantnagar**,** HWEOM-C I was highest (0.157 mg $g^{-1}$) in T3 (50%NPK+50%N-FYM). T5 treatment (50%NPK+50%N-GM) and T2 (100% NPK) both shows non-significant variation followed by T4 (50%NPK+50%N-CR). HWEOM-C II was highest (0.256 mg $g^{-1}$) in T3 (50%NPK+50%N-FYM). All treatments showed increase in HWEOM-C II over control. HWEOM-N was highest in T5 treatment (50%NPK+50%N-GM) followed by T3 (50%NPK+50%N-FYM), T4 (50%NPK+50%N-CR) and T2 (100% NPK) respectively and the increase of HWEOM-N in T5 and T3 were 3.24 and 2.53 times over T1 (control) respectively. The treatment T4 (50%NPK+50%N-CR) and T2 (100%NPK) showed 2.23 and 1.53 times increase in WEOM-N over T1 (Table 5).

It was observed that the HWEOM-C I in 15-30 cm soil samples didn't show much significant variation among the treatments. HWEOM-C I was highest (0.107 mg $g^{-1}$) in T3 (50%NPK+50%N-FYM) and T5 treatment (50%NPK+50%N-GM). T2 (100% NPK) and T4 (50%NPK+50%N-CR) were at par. HWEOM-C II was highest (0.207 mg $g^{-1}$) in T3 (50%NPK+50%N-FYM). T5 treatment (50%NPK+50%N-GM) and T2 (100% NPK) both shows non- significant variation followed by T4 (50%NPK+50%N-CR). HWEOM-N varied significantly in 15-30 cm soil samples among the treatments. The increase of HWEOM-N in T5 and T3 were 3.78 and 2.76 times over T1 (control) respectively. The treatment T4 (50%NPK+50%N-CR) and T2 (100%NPK) showed 2.23 and 1.65 times increase in WEOM-N over T1 (Table 5).

**Table 5:** Long term effect of manuring and fertilization on hot water extractable C and N (HWEOM-C I, II and N) (in mg $g^{-1}$) in 0-15 cm and 15-30 cm soils of Pantnagar.

| Treatments | HWEOM-N | HWEOM-CI | HWEOM-CII | HWEOM-N | HWEOM-CI | HWEOM-CII |
|---|---|---|---|---|---|---|
| | | 0-15 cm | | | 15-30 cm | |
| T1-Control | 0.02e | 0.02c | 0.07d | 0.01e | 0.026c | 0.04a |
| T2-100%NPK | 0.03d | 0.06b | 0.16b | 0.03d | 0.043c | 0.12b |
| T3-50%NPK+50%N- FYM | 0.05b | 0.16a | 0.26a | 0.05c | 0.106a | 0.21a |
| T4-50%NPK+ 50% N-CR | 0.04c | 0.03c | 0.13c | 0.04b | 0.06b | 0.09c |
| T5-50%NPK+ 50% N-GM | 0.06a | 0.08b | 0.18b | 0.06a | 0.106a | 0.15b |

§The data followed by different lowercase letters are significant according to Duncan's Multiple Range (DMRT) Test at 5% level of significance. Values in the same column followed by different lowercase letters (a–e) are significantly different at P=0.05 according to Duncan's Multiple Range Test.

In the soils of Jabalpur, HWEOM-C I in 0-15 cm soil samples showed significant variation among the treatments (Table 6). HWEOM-C I was highest (0.347 and 0.197 mg $g^{-1}$) in T3 (50%NPK+50%N-FYM) followed by T2 (100% NPK). HWEOM-C II in 0-15 cm soil samples showed significant variation among the treatments. HWEOM-C II was highest (0.447 mg $g^{-1}$) in T3 (50%NPK+50%N-FYM) followed by T2 (100%NPK), T4 (50%NPK+50%N-CR) and T5 treatment (50%NPK+50%N-GM) respectively. All treatments showed increase in HWEOM-C II over control. HWEOM-N was highest in T5 treatment (50%NPK+50%N-GM) followed by T3 (50%NPK+50%N-FYM), T4 (50%NPK+50%N-CR) and T2 (100% NPK) respectively and the increase of HWEOM-N in T5 and T3 were 3.37 and 2.78 times over T1 (control) respectively (Table 6).

HWEOM-C I in 15-30 cm soil samples showed significant variation among the treatments. HWEOM-C I was highest (0.267,0.150 and 0.093 mg $g^{-1}$) in T3 (50%NPK+50%N-FYM) followed by T2 (100% NPK), T4 (50%NPK+50%N-CR) respectively. HWEOM-C II in 15-30 cm soil samples showed significant variation among the treatments. HWEOM-C II was highest (0.400 mg $g^{-1}$) in T3 (50%NPK+50%N-FYM) followed by T2 (100%NPK), T4 (50%NPK+50%N-CR) and T5 treatment (50%NPK+50%N-GM) respectively. All treatments showed increase in HWEOM-C II over control. HWEOM-N in T5 and T3 were 4.30 and 2.90 times over T1 (control) respectively. The treatment T4 (50%NPK+50%N-CR) and T2 (100%NPK) showed 2.26 and 1.60 times increase in WEOM-N over T1 (Table 6).

**Table 6:** Long term effect of manuring and fertilization on hot water extractable C and N (HWEOM-C I, II and N) (in mg $g^{-1}$) in 0-15 cm and 15-30 cm soils of Jabalpur.

| Treatments | HWEOM-N | HWEOM-CI | HWEOM-CII | HWEOM-N | HWEOM-CI | HWEOM-CII |
|---|---|---|---|---|---|---|
| | | 0-15 cm | | | 15-30 cm | |
| T1-Control | 0.017 e | 0.06d | 0.14e | 0.01a | 0.013e | 0.1e |
| T2-100% NPK | 0.03d | 0.19b | 0.20d | 0.02d | 0.043d | 0.25b |
| T3-50%NPK+50% N-FYM | 0.03c | 0.34a | 0.23c | 0.043b | 0.120a | 0.40a |
| T4-50%NPK+50% N-CR | 0.04b | 0.15c | 0.29b | 0.034c | 0.057c | 0.19c |
| T5-50%NPK+50% N-GM | 0.05a | 0.13c | 0.44a | 0.064a | 0.077b | 0.106e |

§The data followed by different lowercase letters are significant according to Duncan's Multiple Range (DMRT) Test at 5% level of significance. Values in the same column followed by different lowercase letters (a–e) are significantly different at P=0.05 according to Duncan's Multiple Range Test.

In soils of Ranchi, HWEOM-C I in 0-15cm was highest (0.137,0.093and 0.063 mg $g^{-1}$) in T3 (50%NPK+50%N-FYM) followed by T5 treatment (50%NPK+50%N-GM), T4 (50%NPK+50%N-CR) and T2 (100% NPK) respectively. All treatment showed increased HWEOM-C I over control. HWEOM-C II in 0-15 cm soil samples didn't show much significant variation among the treatments. HWEOM-N varied significantly in 0-15 cm soil samples among the treatments (Table 7). HWEOM-N was highest in T5 treatment (50%NPK+50%N-GM) followed by T3 (50%NPK+50%N-FYM), T4 (50%NPK+50%N-CR) and T2 (100% NPK) respectively and the increase of HWEOM-N in T5 and T3 were 4.77 and 3.49 times over T1 (control) respectively. The treatment T4 (50%NPK+50%N-CR) and T2 (100%NPK) showed 2.60 and 1.60 times increase in WEOM-N over T1.

HWEOM-C I in 15-30 cm soil samples showed significant variation among the treatments. HWEOM-C I was highest (0.120,0.076 and 0.057 mg $g^{-1}$) in T3 (50%NPK+50%N-FYM) followed by T5 treatment (50%NPK+50%N-GM) and T4 (50%NPK+50%N-CR) respectively. All treatment showed increased HWEOM-C I over control. HWEOM-C II in 15-30 cm soil samples didn't show much significant variation among the treatments (Table 7). HWEOM-C I was highest (0.170 mg $g^{-1}$) in T3 (50%NPK+50%N-FYM). T4 (50% NPK+N-CR) was at par with T1 (control). HWEOM-N varied significantly in 15-30 cm soil samples among the treatments (Table 7). HWEOM-N in T5 and T3 were 6.87 and 4.83 times over T1 (control) respectively. The treatment T4 (50%NPK+50%N-CR) and T2 (100%NPK) showed 3.33 and 2.41 times increase in WEOM-N over T1.

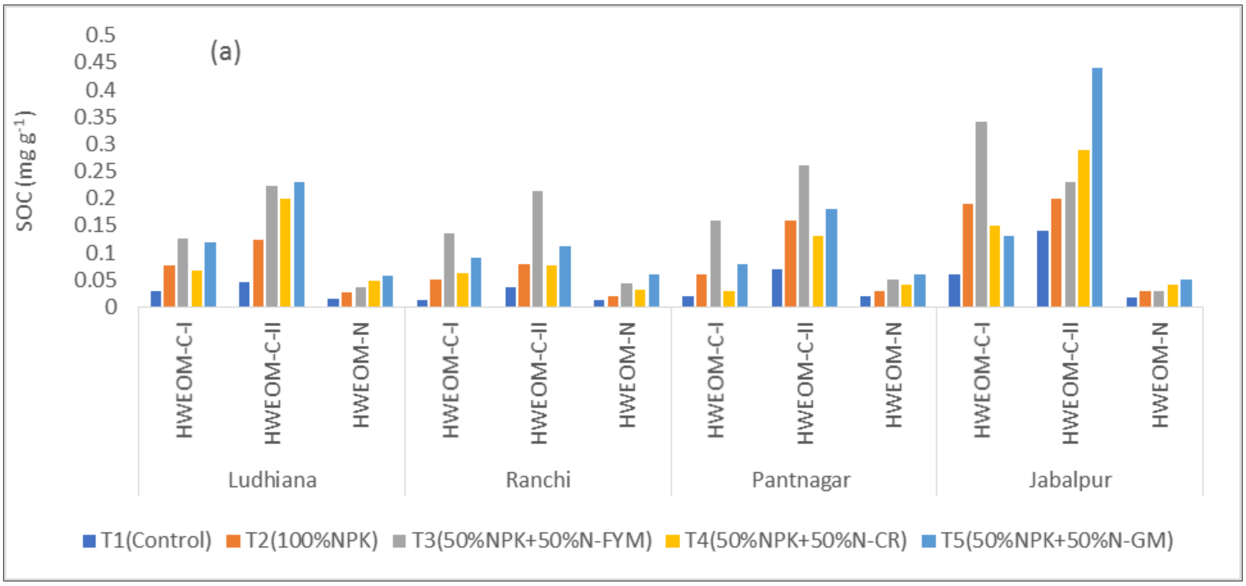
**Table 7:** Long term effect of manuring and fertilization on hot water extractable C and N (HWEOM-C I, II and N) (in mg $g^{-1}$) in 0-15 cm and 15-30 cm soils of Ranchi.

| Treatments | HWEOM-N | HWEOM-CI | HWEOM-CII | HWEOM-N | HWEOM-CI | HWEOM-CII |
|---|---|---|---|---|---|---|
| | 0-15 cm | | | 15-30 cm | | |
| T1-Control | 0.012e | 0.013e | 0.037c | 0.008e | 0.013e | 0.023a |
| T2-100%NPK | 0.020d | 0.05d | 0.080b | 0.019d | 0.043d | 0.067b |
| T3-50%NPK+50%N- FYM | 0.043b | 0.136a | 0.213a | 0.039b | 0.120a | 0.170a |
| T4-50%NPK+50%N-CR | 0.032c | 0.063c | 0.077b | 0.029c | 0.057c | 0.04ab |
| T5-50%NPK+50%N-GM | 0.059a | 0.093b | 0.113b | 0.055a | 0.077b | 0.070b |

§The data followed by different lowercase letters are significant according to Duncan's Multiple Range (DMRT) Test at 5% level of significance. Values in the same column followed by different lowercase letters (a–e) are significantly different at P=0.05 according to Duncan's Multiple Range Test.

## 4. Discussion

Our study clearly demonostrated that the Hot water extractable carbon (HWEOM-C I,II) was highest in 50%NPK+50%N-FYM in both the soil depths for Mollisol, Vertisol and Alfisol but in Inceptisol HWEOM-C I was highest in 50%NPK+50%N-FYM and HWEOMC-II in 50%NPK+50%N-GM in both the soil depths (Fig.1). Hot water extractable nitrogen (HWEOM-N) was highest in 50%NPK+50%N-GM for all soil orders in both the soil depths. The hot water extractable carbon (HWEOM-C) showed variable results across different soils. The 50%NPK+50%N-GM in Inceptisol and Vertisol and 50%NPK+50%N-FYM FYM in Alfisol and Mollisol showed higher amount of HWEOM-C. The HWEOM-C might be representing different fractions of moderately resistant pool of carbon which is not extracted by cold water. Therefore, in FYM treated soil showed relatively higher amount of HWEOM-C than the other treatments. Besides this, the soil type and different green manuring crops with different biochemical recalcitrance might have played a greater role especially in Inceptisol and Vertisol. The increase in water soluble C with application of inorganic N fertilizers could be as a result of the priming effect of applied inorganic N on fresh organic material in the soil which stimulates the microbial activity helping in the decomposition of SOM with rapid release of the DOC fraction (Leon *et al*., 2015) [19]. Contrarily, Sharma *et al*. (2017) [26] reported that GM management resulted in (i) a substantial increase in dissolved organic C concentration, (ii) GM-HWEOM becoming enriched by hydrophilic aliphatic organic compounds. It is quite obvious that green manuring crops richer nitrogen content and narrower in C: N might contribute more towards easily degradable part of organic matter unlike other materials like CR or FYM. The beneficial effect of FYM application under rice-wheat cropping system on DOC content was also reported by others (Manna *et al.,* 2005, Brar *et al.,* 2013) [22,6]. After 11 years of experiment, there was improvement in WEOC, HWOC, $KMnO_4$-C, easily-oxidizable fraction, $C_{min}$, and MBC by applications of farmyard manure and rice CR. During the 11-year period, the greatest increase was observed in WEOC and the minimum in $KMnO_4$-C. All other labile SOC pools had the same sensitivity to management as TOC. Most of the SOC pools were positively correlated to each other though their amounts differed considerably (Benbi *et al.,* 2015) [3].



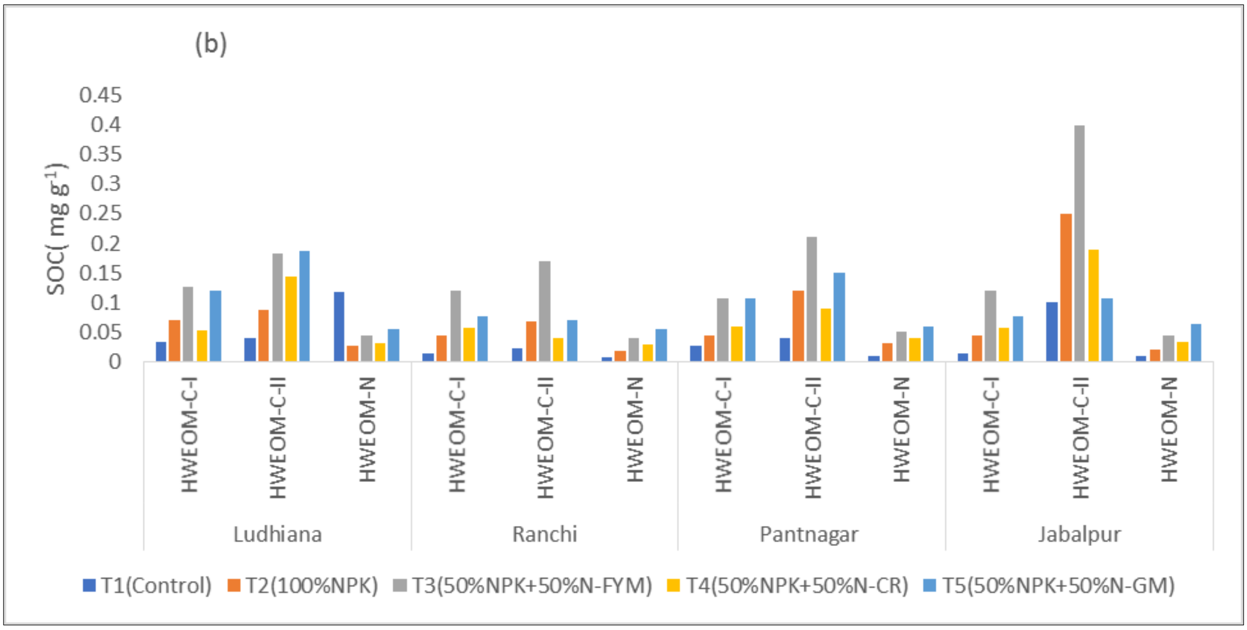




**Fig 1:** Level of hot water extractable organic matter carbon-I and II (HWEOM-C-I, II) and hot water extractable nitrogen (HWEOM-N) in 0-15 cm soil depth (a) and 15-30cm soil depth (b) as affected by long term fertilization and manuring in four soil types of India.

Majumder *et al*. (2007) [20] also have reported the components of SOC pools viz., signify normal carbon, oxidisable regular carbon and its four particular segments, for instance, to a great degree labile, labile, less labile and non-labile carbon, microbial biomass carbon, mineralizable carbon, and particulate common carbon in association with varying productivity using a multi-years old rice–wheat–jute cropping sequence with different organization techniques in the hot moist, subtropics of India.

## 5. Conclusion

As interest increases in both promoting organic C storage, it is crucial to understand the relative sequestration efficiency of added C source as well as its stability in the soil. Optimum levels of soil organic matter (SOM), its labile and recalcitrant pools can be managed through crop rotation, fertility maintenance including use of inorganic fertilizers and organic manures, tillage methods, and other cropping system components. Among these management practices, proper cropping systems and balanced fertilization are believed to offer the greatest potential for increasing SOC storage in agricultural soils. In this regard, 50%NPK+50%N-through organic sources has been proven to be a potent nutrient management practices for enhancing labile pools of SOM like HWEOM-C and N depending upon soil type, climatic condition and management practices. Also being closely related to soil microbial biomass and micro-aggregation, these could therefore be used as one of the soil quality indicators.

## 6. Acknowledgement

I am thankful to the Indian Council for Agricultural Research and Indian Agricultural Research Institute, New Delhi for providing the research fellowship support to carry out this research work.

## 7. References

1. Abrol IP, Bronson KF, Duxbury JM, Gupta RK. Long-term soil fertility experiments in rice-wheat cropping systems. eds (No. REP-8540. CIMMYT), 2000.
2. Andrews SS, Karlen DL, Cambardella CA. The soil management assessment framework: A quantitative soil quality evaluation method. Soil Science Society of America Journal. 2004; 68:1945-1962.

3. Benbi DK, Brar K, Toor AS, Singh P. Total and labile pools of soil organic carbon in cultivated and undisturbed soils in northern India. Geoderma. 2015; 237:149-158.
4. Benbi DK, Brar K, Toor AS, Singh P. Total and labile pools of soil organic carbon in cultivated and undisturbed soils in northern India. Geoderma. 2015; 237:149-158.
5. Bhaduri D, Purakayastha TJ. Long-term tillage, water and nutrient management in rice–wheat cropping system: Assessment and response of soil quality. Soil & Tillage Research. 2014; 144:83-95.
6. Biswas S, Hazra GC, Purakayastha TJ, Saha N, Mitran T, Singha Roy S *et al*. Establishment of critical limits of indicators and indices of soil quality in rice-rice cropping systems under different soil orders. Geoderma. 2017; 292:34-48.
7. Brar BS, Singh K, Dheri GS. Carbon sequestration and soil carbon pools in a rice–wheat cropping system: effect of long-term use of inorganic fertilizers and organic manure. Soil and Tillage Research. 2013; 128:30-36.
8. Ding G, Liu X, Herbert S, Novak J, Amarasiriwardena D, Xing B. Effect of cover crop management on soil organic matter. Geoderma. 2006; 130:229-239.
9. Doran JW, Parkin TB. Defining and assessing soil quality. Defining soil quality for a Sustainable Environment. 1994; 87:1-21.
10. Ghani A, Dexter M, Perrott KW. Hot-water extractable carbon in soils: A sensitive measurement for determining impacts of fertilisation, grazing and cultivation. Soil Biology and Biochemistry. 2003; 35:1231-1243.
11. Ghani WAWAK, Mohd A, da Silva G, Bachmann RT, Taufiq-Yap YH, Rashid U *et al*. Biochar production from waste rubber-wood-sawdust and its potential use in C sequestration: chemical and physical characterization. Industrial Crops and Products. 2013; 44:18-24.
12. Gutiérrez-Girón A, Díaz-Pinés E, Rubio A, Gavilán RG. Both altitude and vegetation affect temperature sensitivity of soil organic matter decomposition in Mediterranean high mountain soils. Geoderma. 2015; 237:1-8.
13. Haynes RJ. Labile organic matter fractions as central components of the quality of agricultural soils: an overview. Advances in Agronomy. 2005; 85:221-268.
14. Janzen HH, Campbell CA, Brandt SA, Lafond GP, Townley Smith L. Light-fraction organic matter in soils from long-term crop rotations. Soil Science Society of America Journal. 1992; 56:1799-1806.
15. Kaiser K, Kalbitz K. Cycling downwards–dissolved organic matter in soils. Soil Biology and Biochemistry. 2012; 52:29-32.
16. Kanchikerimath M, Singh D. Soil organic matter and biological properties after 26 years of maize–wheat–cowpea cropping as affected by manure and fertilization in a Cambisol in semiarid region of India. Agriculture, Ecosystems and Environment. 2001; 86:155-162.
17. Karlen DL, Stott DE. A framework for evaluating physical and chemical indicators of soil quality. Defining soil quality for a sustainable environment, 1994, 53-72.
18. Krull ES, Baldock JA, Skjemstad JO. Importance of mechanisms and processes of the stabilisation of soil organic matter for modelling carbon turnover. Functional Plant Biology. 2003; 30:207-222.
19. Ladha JK, Dawe D, Pathak H, Padre AT, Yadav RL, Singh B *et al*. How extensive are yield declines in long-term rice–wheat experiments in Asia? Field Crops Research. 2003; 81:159-180.
20. Leon A, Kohyama K, Takata Y, Yagi K, Umemiya Y, Ohkura T *et al*. Change in soil carbon in response to organic amendments in orchards and tea gardens in Japan. Geoderma. 2015; 237:168-175.
21. Majumder B, Mandal B, Bandyopadhyay PK, Chaudhury J. Soil organic carbon pools and productivity relationships for a 34 years old rice–wheat–jute agroecosystem under different fertilizer treatments. Plant and soil. 2007; 297:53-67.
22. Manna MC, Bhattacharyya P, Adhya TK, Singh M, Wanjari RH, Ramana S *et al*. Carbon fractions and productivity under changed climate scenario in soybean–wheat system. Field Crops Research. 2013; 145:10-20.
23. Manna MC, Swarup A, Wanjari RH, Ravankar HN, Mishra B, Saha MN *et al*. Long-term effect of fertilizer and manure application on soil organic carbon storage, soil quality and yield sustainability under sub-humid and semi-arid tropical India. Field Crops Research. 2005; 93:264-280.
24. McDowell WH. Dissolved organic matter in soils-future directions and unanswered questions. Geoderma. 2003; 113:179-186.
25. Nayak AK, Gangwar B, Shukla AK, Mazumdar SP, Kumar A, Raja R *et al*. Long-term effect of different integrated nutrient management on soil organic carbon and its fractions and sustainability of rice–wheat system in Indo Gangetic Plains of India. Field Crops Research. 2012; 127:129-139.
26. Reeves DW. The role of soil organic matter in maintaining soil quality in continuous cropping systems. Soil and Tillage Research. 1997; 43:131-167.
27. Sharma P, Laor Y, Raviv M, Medina S, Saadi I, Krasnovsky A *et al*. Green manure as part of organic management cycle: Effects on changes in organic matter characteristics across the soil profile. Geoderma. 2017; 305:197-207.
28. Singh S, Ghoshal N, Singh KP. Synchronizing nitrogen availability through application of organic inputs of varying resource quality in a tropical dryland agroecosystem. Applied soil ecology. 2007; 36(2-3):164-175.
29. Smolander A, Kitunen V. Soil microbial activities and characteristics of dissolved organic C and N in relation to tree species. Soil Biology and Biochemistry. 2002; 34:651-660.
30. Snyder JD, Trofymow JA. A rapid accurate wet oxidation diffusion procedure for determining organic and inorganic carbon in plant and soil samples. Communications in Soil Science and Plant Analysis 1984; 15:587-597.
31. Tiessen HJWB, Stewart JWB. Particle-size Fractions and their Use in Studies of Soil Organic Matter: II. Cultivation Effects on Organic Matter Composition in Size Fractions 1. Soil Science Society of America Journal. 1983; 47:509-514.
32. Tisdall JM, Oades J. Organic matter and water-stable aggregates in soils. European Journal of Soil Science. 1982; 33:141-163.
33. Veihmeyer FJ, Hendrickson A. Soil density and root penetration. Soil science. 1948; 65(6):487-494.
34. Wiaux F, Cornelis JT, Cao W, Vanclooster M, Van Oost K. Combined effect of geomorphic and pedogenic processes on the distribution of soil organic carbon quality along an eroding hillslope on loess soil. Geoderma. 2014; 216:36-47.