

**University of Eswatini**

**Department of Chemistry**

**November 2018 Main Examination**

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**TITLE OF PAPER** : Research Methods

**COURSE NUMBER** : CHE 303

**TIME** : 2 Hours

**Important Information** : Answer question 1 and two (2) other questions

*You are not supposed to open this paper until permission has been granted by the Chief Invigilator*

**Question 1: Compulsory [40 Marks]**

- a) Identify a topic of your choice that could be the focus of a research study in Water treatment and water resource management, and write three research objectives that could be addressed in this topic. [10]
- b) “A literature review is, without question, a key part of anyone’s research; it is more than a mere summary of research studies and findings”.
- i. What are the major purposes of carrying a literature review? [15]
  - ii. What are the steps that a researcher should bear in mind so as to conduct a literature review? [15]

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**Question 2 [30 Marks]**

- a) List the qualities of a good research [10]
- b) From the attached research article; identify the research problem and the research objectives [5]
- c) From the same article used in (b) above, write a conclusion (not more than 200 words) [15]

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**Question 3 [30 Marks]**

- a) There are various ways of evaluating the quality of data obtained in Scientific research; List and describe three ways of data quality verification [5]
- b) A new procedure is developed for the analysis of antibodies in patients. 5 measurements are taken using the new method, (11,7; 10,5; 10,6; 11,2 and 9,8 ) and the listed value from another validated method is 11,7 mg/L [10]
- c) The research process can be summarized in a sequence of steps which defines a systematic procedure for the objectives of a research to be met. Describe the sequence of steps involved. [10]
- d) Define simple random sampling and give an example where it would work [5]
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**Question 4 [30 Marks]**

- a) List four major methods of collecting data and explain their differences. [8]
- b) Scientific research is methodic and requires clearly define steps to be followed. In this view, a respected scientist was quoted to have said *“To satisfy our doubts., it is necessary that a method be found by which our beliefs may be determined by nothing human, but by some external permanency – by something upon which our thinking has no effect. The method must be such that the ultimate conclusion of every man shall be the same. Such is the method of science”*. Comment on the quote based on what you understand of scientific research [10]
- c) Compare and contrast between induction and deduction, as used in research [7]
- d) Describes alternatives to research [5]

**The End**

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## SHORT COMMUNICATION

HOT-WATER-SOLUBLE C AS A SIMPLE MEASURE OF  
LABILE SOIL ORGANIC MATTER: THE RELATIONSHIP  
WITH MICROBIAL BIOMASS C

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Many monitoring programs advocate that soil organic matter contents should be measured to assess effects of land use on soil quality. Rates of change in the total organic pool are relatively slow and other more labile soil C pools, such as soil microbial C, have been suggested as more sensitive indices to monitor longer-term trends in organic matter (Powelson *et al.*, 1987; Doran and Parkin, 1994; Larson and Pierce, 1994; Gregorich *et al.*, 1994). The fumigation-extraction methods to determine microbial C (Vance *et al.*, 1987) are relatively complex and time-consuming, which could limit their inclusion in routine monitoring programs. In contrast, water extracts of moist and air-dried soils are simple to obtain and can provide a labile C fraction (McGill *et al.*, 1986; Davidson *et al.*, 1987; Haynes and Swift, 1990; Zsolnay and Gortlitz, 1994; DeLuca and Keeney, 1994; Harris and Safford, 1996). Cold-water extracts from moist soil contain very little C derived from microbial cells (van Ginkel *et al.*, 1994), and there is poor agreement between the microbial biomass C and amounts of soluble C extracted from moist soils (DeLuca and Keeney, 1994). However, extracts from dried, fumigated or partially-sterilized soil contain much greater amounts of soluble C, some of which is derived from killed microbial cells (Powelson and Jenkinson, 1976; Vance *et al.*, 1987; West *et al.*, 1989; Badalucco *et al.*, 1992). Blagodatskyi *et al.* (1987) used soil desiccation as an alternative to fumigation to release microbial C and, on a very limited range of soils, Sikora *et al.* (1994) found good agreement between microbial biomass measured by the desiccation method, by fumigation-extraction or the substrate-induced respiration methods.

The proportion of soil organisms surviving air-drying can be variable, clays and organic matter

protect against desiccation and there may have been selection for drought tolerant organisms (Powelson and Jenkinson, 1976; Sparling *et al.*, 1986). To maximize the amount of microbial material in a water extract of dry soils it will be necessary to solubilize the surviving cells. Boiling water at 100°C kills vegetative microbial cells (Stanier *et al.*, 1968) but has the disadvantage of extracting appreciable amounts of non-microbial organic C (Haynes and Swift, 1990). A temperature of 70°C is sufficient to kill vegetative microbial cells (Stanier *et al.*, 1968) and still makes microbial biomass components extractable (Speir *et al.*, 1986). Our preliminary studies on conditions to extract microbial C suggested a suitable combination was to air-dry soil at 20–25°C followed by a water extraction at 70°C for 18 h. We report results obtained using this approach compared against those obtained by fumigation-extraction.

Soils from a wide range of locations in New Zealand were sampled to 0–10 cm depth. Also included were a small number of peats and subsoils sampled to greater depths (Table 1). The soils were sieved (<4 mm) while field moist, adjusted to –5 kPa moisture content, and conditioned at 25°C for 7 d before measuring microbial biomass (triplicates) of the moist soil by the fumigation-extraction technique (Vance *et al.*, 1987). Exceptions were the peats and the sawdust amended soil for which the microbial biomass was measured without conditioning and peats were cubed (1 cm) rather than sieved. A *k*-factor of 0.41 was used to calculate microbial C from the C-flush. A small (*ca.* 100 g) subsample of the soil was spread thinly on plastic sheeting and air-dried at 20–25°C for up to 96 h. The air-dried soil was stored in sealed plastic jars at ambient laboratory temperature (18–22°C) until analyzed (triplicates) for water-soluble components up to 6 months later. Hot-water soluble C was obtained by incubating 2 g air-dry soil or 0.4 g peat with

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soils, and up to  $10.6 \text{ mg g}^{-1}$  in the peats. Hot-water-extractable C ranged from  $1 \mu\text{g g}^{-1}$  in the subsoils up to  $1068 \mu\text{g g}^{-1}$  in topsoils and  $12.2 \text{ mg g}^{-1}$  in peats. Replicates generally differed by  $< 5\%$ , and mean values for each soil were used for regression analyses.

Overall, there was a linear relationship (Fig. 1) between total C and hot-water-extractable C ( $R^2 = 0.86$ ,  $n = 66$ ,  $P < 0.001$ ). This correlation was biased by two groups of soils forming clear outliers: the sawdust-amended (Anthropogenic) soil, and peaty soils with a total C content  $> 10\%$ . Excluding these soils from the regression because of their high leverage gave the regression ( $\pm$  standard errors of parameters): water-extractable C =  $105 \pm 11$  (Total C) -  $25 \pm 52$  ( $R^2 = 0.63$ ;  $n = 53$ ;  $P < 0.001$ ).

Generally, there was a linear relationship and reasonable correlation between hot-water extractable C and microbial biomass C ( $R^2 = 0.79$ ,  $n = 66$ ,  $P < 0.001$ ). The sawdust-amended soil and peaty soils again formed outlier points. Regression analyses excluding these soils (Fig. 2) gave the relationship: water-extractable C =  $0.43 \pm 0.39$  (microbial biomass C) +  $77.3 \pm 40.5$  ( $R^2 = 0.71$ ;  $n = 53$ ,  $P < 0.001$ ), demonstrating a closer agreement than between water-extractable C and total C. Extending this relationship to the microbial quotient (microbial C/Total C percentage) and the analogous water-extractable C/total C percentage, showed a general agreement between the two ratios, but revealed subsoils with very low biomass as a distinct group of outliers. These subsoils were also excluded from analyses (Fig. 3). Regression analyses gave the relationship  $y = 0.30x + 0.44$  ( $R^2 = 0.47$ ,  $n = 47$ ,  $P < 0.001$ ).

In our study, the hot-water-extractable C content of the mineral soils after air drying was about 43% of the microbial C, although there was considerable variability around this value (C.V. = 9%). The proportion of microbial C becoming extractable was similar to the 40–45% of the microbial C, obtained by fumigation-extraction (Wu *et al.*, 1990; Joergensen, 1996). This similarity may be coincidental, because in some cases non-microbial pools definitely contributed to the hot water-extractable C. This was especially so with soils of organic C contents  $> 10\%$ , where, in some instances, more C was extracted in hot water than was originally present in the microbial biomass. We regard hot water extractable C as a measure of labile soil C, not necessarily a substitute for microbial C. However, for topsoils with  $< 10\%$  organic C, water-extractable C was more closely related to the microbial biomass C than total C. The ratio of water extractable C-to-total C could be used in an analogous way to the microbial quotient which has been proposed for soil quality monitoring (Doran and Parkin, 1994). The method requires further validation on other

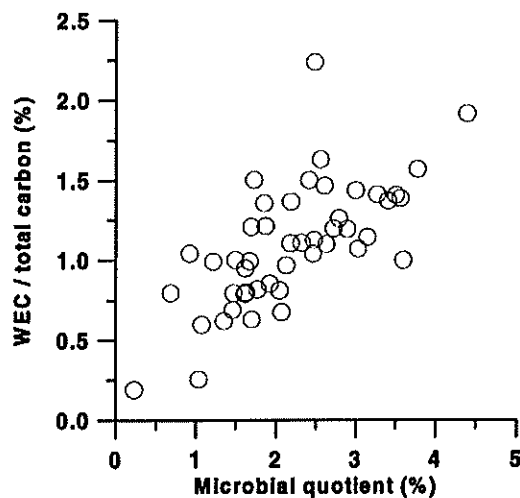


Fig. 3. Relationship between the microbial quotient (microbial C/total C) and the ratio of water-extractable C-to-total C.

soils but is worthy of attention for wide scale soil quality monitoring in that it is simple, rapid, does not require toxic fumigants, and the soils may conveniently be stored in an air-dry state at room temperature until analyzed.

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