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Characterization of Organic Waste Used as Bio-fertilizers: Case of Potato Peelings, Almond Hulls and Shrimp Shells

Mamouni F.Z
Unit "Materials and Applied Catalysis", Faculty of Science, University Moulay Ismail, Meknes.
Unit Research Agronomy and Plant Physiology, Regional Center for Agricultural Research, Meknes.

Razouk R
Unit Research Agronomy and Plant Physiology, Regional Center for Agricultural Research, Meknes.

Kajji A
Unit Research Agronomy and Plant Physiology, Regional Center for Agricultural Research, Meknes.

Daoui K
Unit Research Agronomy and Plant Physiology, Regional Center for Agricultural Research, Meknes.

El Ouali A
Unit «Science of Water and Environmental Engineering» Faculty of Science, University Moulay Ismail, Meknes.

Boukhlifi F
Unit "Materials and Applied Catalysis", Faculty of Science, University Moulay Ismail, Meknes.

Abstract – **The use of organic waste in crop fertilization has two advantages. On the one hand, it allows to acquire a source of organic fertilizers by cheaper price, on the other hand, it is a promising technique for attenuation of pollutant power of these wastes. In this context, a valuation study of the bio-fertilizers, potato peelings (PP), almond hulls (AH) and shrimp shells (SW), was initiated. These wastes are previously dried and finely ground. A first test was started on common wheat (cv. Arrehane) in jars (1/3 sand and 2/3 ground) by testing four doses of each waste separately, corresponding to 100, 150, 200 and 300% of requirements of common wheat in fertilization (90-90-50 kg / ha) in terms of nitrogen peeled the potatoes and shrimp shells and phosphorus term for almond hulls. The choice of this experimental approach was based on chemical analyzes of the three waste showed that peeled the potatoes and shrimp shells are an important source of nitrogen with averages of 16.2 and 49.8 respectively kg / ton, however, almond hulls are a good source of phosphorus with an average of 2.4 kg / ton. The test pots was installed earlier this 2014-2015 campaign in October. The measures concern the monitoring of soil fertility, particularly in terms of total nitrogen, phosphorus, potassium and organic matter and the nutritional status of wheat and its yield components and compared two witnesses pots without no manuring (control 1) and pots fertilized by conventional fertilizer (90-90-50 equivalent to kg / ha) (Control 2). The recovery of organic waste into bio-fertilizers on the one hand and the reduction of pollution caused by these other waste, give this search fallout of great interest on agricultural and environmental levels.**

Keywords – **Characterization, Organic Waste, Bio-fertilizer, Potato Peelings, Almond Hulls and Shrimp Shells.**

I. Introduction

Population growth puts down numerous challenges, including increased demand for food. Consequently, the waste production increased in terms of quantity and quality, especially in developing countries (DCs), thus causing negative impacts on the environment and consequently on human health [1]. Morocco generates a volume of 18,772 tons/day of household refuses, divided among organic waste (65%), plastics (10%), paper and cardboard (10%), metals (4%) and glass (3%)[2].In general, the Moroccan consumption of organic products is 85%, they includes vegetables, fruits and tea products with an average annual consumption respectively of 5.841.440, 2.076.946 and 138.740 tons[3]. Thus, the average annual consumption per person is approximately 167 kg of vegetables and 60kg of fruits. Furthermore, several experiments have shown that vegetables and fruits generates, after use, respectively 17% and 30% of waste. Then, the final composition of the organic fraction about solid household waste obtained from the annual consumption average, the amount of waste by species and population is 37% of vegetable and 35% of fruit wastes[4].

Consequently, those organic wastes are often laid down anarchically in the wrong or non-controlled landfills, this is the one of the crucial public health of neighboring population and environment issues[5]. The governments and African municipalities faced on [6].

Several studies have focused on the chemical characterization of organic waste [7]. Some of them had as primary objective evaluation of the pollutant potential of the waste [8] or the identification of the adverse effects on population health and environment. [9]

For our work, the principal objective is rather the revelation of fertilizing waste power, and therefore see the positive side and consider them as a source of bio-fertilizers and not just as a source of pollution.

The transformation of organic waste into bio-fertilizers allows reducing their polluting power which involves lixiviation as well as acquisition of source of organic matter fertilizer less expensive or even free. In this framework, our research topic guides to study the fertilizing power of three types of organic waste that are: peels potatoes (PP), almond hulls (AH) and shrimp waste (SW). To do this, physicochemical analyzes showed their richness of elements N, P, K. The application of increasing doses of waste on common wheat, variety Arrehane, was conducted in pots respecting the fertilizers needs of this plant.

II. Materials and Methods

A. *Preparation of Waste Samples*

Potato peels (tuber skin), almond hulls and shrimp waste (head, thoracic and abdominal shell, carapace, telson, appendages, antennae, maxillary case)were collected: The first in our homes, the second at a seller of almonds (district S. Bouzekri in Meknès city, Morroco) and the last in two markets of fishery resources (in Hamriya and Lhdim in Meknès city, Morroco). Those wastes are dried in an oven for two days at a temperature of 80 ° C (for PP and SW) and of 105°C (for AH). Then, are manually and mechanically crushed and sieved to 2 mm (Figure 1).

Fig. 1. Photos of waste samples (a): PP, (b): AH, (c): SW

B. Physicochemical Analysis of Wastes

The analysis are conducted in National Agricultural Research Institute (INRA) of Meknes, Morocco, they focused on the pH, nitrogen (N), phosphorus (P), potassium (K) and organic matter.

The pH measurement was carried with the apparatus pH 3000 STEP Systems GmbH. The nitrogen assay was performed according to the Kjeldahl method. The phosphorus and potassium assays were made by the laboratory protocol using respectively sodium bicarbonate and ammonium acetate and employing successively the spectrophotometer (JENWAY SPECTRO-PHOTOMETER 7305) and the flame photometer (100 AFP1 FLAMEPHOTOMETER).The organic matter (OM) is determined after calcination of waste samples in the oven at 500 °C for 4 hours. Besides, IR and XRD analyses are made in Faculty of science in Meknès. The dry matter (DM) content was assessed after drying our waste samples.

FTIR spectroscopy : Infrared spectroscopy were recorded by using a Spectrophotometer Fourier transform Type JASCO 4100, provided with a detector triglycinesulphate (TGS) using at form of pellets (5 mg of waste sample with 95 mg of solid KBr).

X-ray analysis : The X-ray diffraction (XRD) patterns was obtained using a X'PERT MPD-PRO wide 22 angle X-ray powder diffractometer provided with a diffracted beam monochromator and Ni 23 filtered CuKα radiation (λ = 1.5406 Å). The voltage was 45 kV and the intensity 40 mA. The 24 2° angle was scanned between 4° and 60°, and the counting time was 2.0 s at each angle step 25 (0.02°).

C. Cultivation of Common Wheat

The determination of organic inputs for each waste in kg/ton in terms of N, P and K is made based on the results of analyzes in the laboratory, they are respectively for the three wastes: SW, AH and PP 49.8; 2.4 and 4.42 kg/ton.

III. Results and Discussion

A. Physico-Chemical Analyzes

The results correspond to physico-chemical analyzes are shown in Table 1.

The contents of nitrogen, phosphorus, potassium, organic matter, and the ratio C/N are conferred to international standards about AFNOR,Norm NF U44-051 homologous in 2006, for assessing organic substances issues from a carbonated combination of vegetable, animal matters or their mixture and re-used as improvements [10], which are specified in some properties below:

1. content in DM≥ 30% of RM, (dry matter, raw matter)
2. content in OM ≥ 20% of RM, according to denominations,
3. total content in N and P2O5 and K2O < 3% of RM,
4. content in N + P2O5 + K2O < 7% of RM,

C/N > 8.

From our results, the chosen biofertilizers ratify almost all the values of AFNOR cited above, so they can join the organic substances re-used as improvements for cultivation.

Indeed, the sum of percentages about the N, P and K is less than 7% for potato peels, almond hulls and shrimp waste which are successively: 2,32; 0,47 and 6,45%. All the percentages for each one of those elements are less than 3% for the three wastes. For about OM, the percentage is superior than 20% for all the samples of wastes. Concerning DM and the factor C/N, the almond hulls have achieved the values superior successively than 30 % and 8. Regarding potato peels and waste shrimps, they have the around values of those ones mentioned before.

According to our analysis, the shrimp waste is rich with nitrogen, potato peels with potassium and almond hulls with phosphorus.


Fig. 2. Stages of the preparation of substratum and seedling

The analysis showed that the composition of shrimp waste (Shrimp solid waste consist of shells, viscera, small portions of attached meat, and associated water) is characterized by its richness in nitrogen, which accorded with several previous works [11]–[12]–[13].

This richness is due to their high content in proteins. A factor of 6.25 was used for converting the total nitrogen to crude protein, the percent of proteins in our sample represents so 31.12%, this value is approximate relatively of those about others researches. Among others authors, reference [14] told that the protein content in dried shrimp waste was 52%. F. Shahidi found too that the crude protein constitute 44.12 ± 0.79% of shrimp's discards[15]. Likewise, H. M. Ibrahim, M. F. Salama and H. A. El-Banna said also that the proteins contents in shell and head of shrimp are successively 47.43 and 47.75%[11].

S. Ravichandran, G. Rameshkumar and A. Rosario Princereported too, in 2009, that the percent of crude protein in dry weight of shrimp waste is 24.03%[16], likewise, the approachable percent (29.3%) was found by K.Prameela, Ch. Murali Mohan, P.V. Smitha and K.P.J. Hemalatha, in 2010[17]. Also, M. Khan and A. K. M. A. Nowsad, in 2012, were found high levels comprising 40 to 50% of proteins in the shell waste[18].

Those results showed too that the shrimp waste is rich in phosphorus, which is in agreement with many authors who found that this content in head and shell was respectively 0.017 and 0.029%[11]. This richness in phosphorus is attributed to his contribution in forming the crustacean structures and strengthing when the phosphorus is combined with calcium. The shrimp waste had an alkaline pH (8.55), this value accords to the one of K. Prameela, Ch. M. Mohan, P.V. Smitha and K.P.J. Hemalatha, 2010, which is 8.10± 0.10[17].

For about analysis of potato peels, our results represent that the potato peels are rich in potassium and nitrogen. They corroborate those of A. U.Mahmood, J. Greenman, and A. H. Scragg, together with, R. B. Toma, P. H.Orr, B. D'Appolonia, F.R.D. lntzlsandand M. M. Tabekhia[19]–[20].The percent of potato peels content in phosphorus is 0,26% which accorded almost the one found by V. Decruyenaere et *al*[22],which is 0,24%. For the plant tissues, Tkachuk said that the factor 6.25 estimates too protein content from the one of nitrogen[23]. Therefore, potato peels are characterized by their content relatively high of proteins, is included between 15 and 19% [21], this result approach nearly ours who is about 10.12%. This explicated the average content of nitrogen who represented the percent of 1,62%,this is in according with the study of R. Maria Kosseva and C. Webb, 2013[24]. For about phosphorus, our result is high for about the one of the quoted author, they said too that the dry matter content vary from 10% to 30% which is in accordance with our result corresponding to 23,06%.

Our results showed that almond hulls are characterized by their richness in phosphorus followed by nitrogen, successively with 0,24% and 0,16%, S. F. Calixto and J. Canellas found the approachable content in phosphorus unlike that of nitrogen is high[25]. The pH and the percents of DM and OM are near than those of M. Valverde, 2013, who found that they are respectively 5,24; 90,01 and 95,40% [26]. The technical slip of Feedipedia (2012) shows too the very proximate values: 86.6 % of DM and 92.7% of OM[27].

B. Results of FTIR Spectroscopy

The graph in figure 3 showed the IR spectra of the used wastes in our work, their overall observation reveal that the composition is different for each sample.

For PP, the different bands are showed in the IR spectrum, some of these are attributed to distinct elongations modes of C-Cl of chlorides alkyls and acids (527-618 and 1031 cm^{-1} respectively) and C-N for amines (1411 cm^{-1}). This elongation is followed by deformation at 1640 cm^{-1} due to the scissor movement of $-NH_2$. At 2926 cm^{-1}, another elongation of carboxylic acids O-H is attributed, then, the inter-molecular elongation for the same group is detected at 3385 cm^{-1}. Therefore, from those peaks, the structure of PP is rich in acids which provides them an acidic pH (Table I).

For about almond hulls, the Infrared spectrum showed two elongations of C-Cl of chlorides alkyls and acids, successively, at 539 and 613 cm^{-1}. The latest functions are followed at 898 $cm^{-1}$by the deformation in the function >N-H of amines I and II.An intense elongation C-O- for the second alcohols >CH-OH at 1121-1244 cm^{-1},was carried on C-O- elongation (1046 cm^{-1}), then was succeeded by bond deformation of O-H phenols at 1331 cm^{-1}. The Tertiobutyle group ($-C(CH_3)_3$) appeared(1381 cm^{-1}), at 1430-1455 cm^{-1} peaks, a deformation bond of $-CH_2$was showed. An elongation of aromatic group >C=C< alternated later (1504cm^{-1}), the scissor movement of $-NH_2$ caused a deformation at the peaks1591-1641 cm^{-1}. Afterwards, a very intense elongation of carboxylic acids was occurred at 1739 cm^{-1}, the aromatic derivatives are presented, between 2024-2371 cm^{-1}, by the bands of harmonic combination "fingerprints". This spectrum is enclosed by –C≡C- elongation with very low intensity at 2024-2371 cm^{-1}.

Table 1: Results of physicochemical analyzes of wastes

Waste/ parameter	pH	DM (%)	OM (%)	C (%)	N (%)	P (%)	K (%)	C/N
PP	5,53	23,06	92	46	1,62	0,26	0,44	28,39
AH	5,06	84,74	96,2	48,1	0,16	0,24	0,07	300,625
SW	8,55	26,13	56	28	4,98	1,42	0,05	5,62

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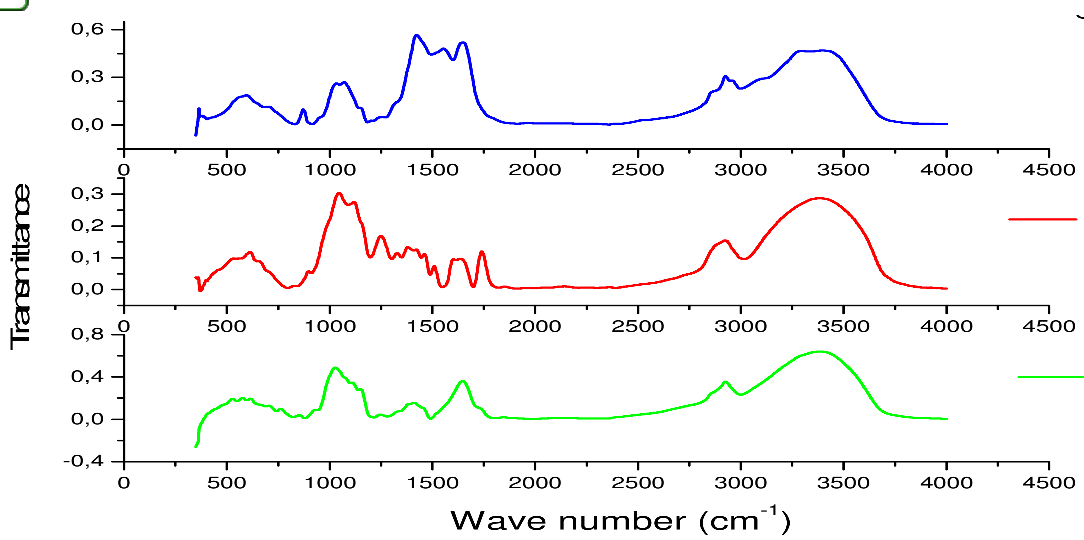
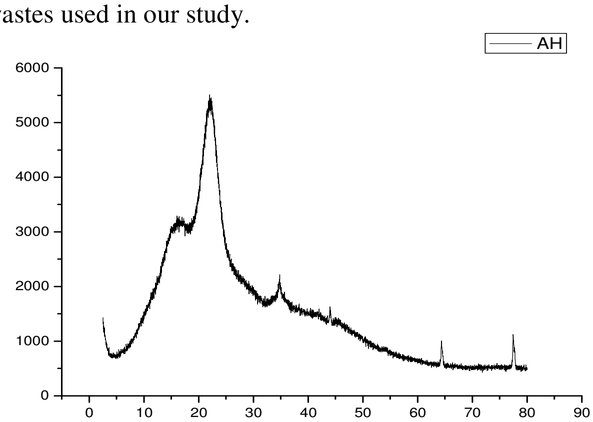


Fig. 3. IR spectrum of SW, AH and PP

The spectrum of shrimp waste sample present in the begin an elongation C-Cl of alkyl chlorides at 591 cm^{-1} succeeded by an aromatic bond C-H (876 cm^{-1}). At 1032-1074 cm^{-1}, another bond C-OH of primary alcohols –CH_2OH appeared and a deformation occurred on in the form of shearing of thebond –CH_2(1425cm^{-1}). Primary amines appeared at 1551 $cm^{-1}$by the bond N-H then amides are revealed too at 1643 $cm^{-1}$when their bond N-H is covered by the one of C=O. At 2923 cm^{-1}, an elongation of O-H of carboxylic acids was developed and the hydrogen bonds done a solidpotato. The spectrum finished by the elongation of N-N for the bond >NH of second amines at 3289-3415cm^{-1}. This spectrum resembles nearly to the one of shrimp chitin in the study of F. Boukhlifi, A. Bencheikh and H. Ahlafi[28].

A. XRD Characterization

The figure bellow shows the graphs of DRX about all wastes used in our study.



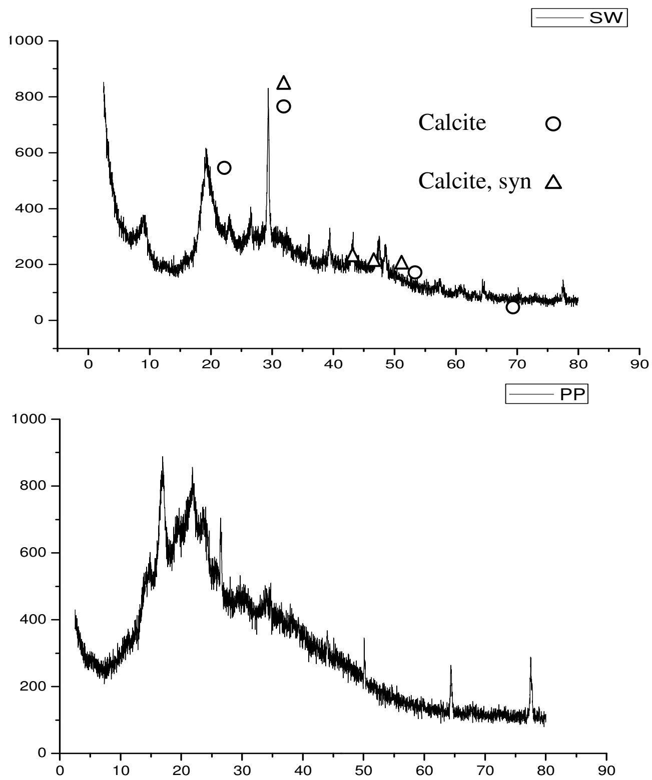


Fig. 4. X Ray diffractogram of PP, AH and SW

XRD is a powerful technique used to unravel potato peelings structures. It is a method used for the analysis of the crystalline structure of materials. The XRD patterns recorded for PP were between 5 and 80 (Fig. 4). PP showed low overall crystallinity. The first graph in figue 4 suggests that PP was a semi-crystalline polymer and that the crystalline region of PP was seen at the angle (2h) 16.96. This result was similar to the one obtained by H. Ahlafi, H. Moussout, F. Boukhlifi, M. Echetna[29]. The diffractogram of SW, shows that the mineral part shells contains a mixture of two varieties of calcium carbonate CaCO3 / Calcite and CaCO3 / calcite, syn.

B. Cultivation of Common Wheat

In order to cultivate the common wheat and adding our bio-fertilizers, we calculated before the doses of those from the analysis results of the three elements N, P, and K (Table 2).

The test is installed in pots with 1/3 of sand and 2/3 of soil (Figure 2). The doses of organic wastes (g / pot) (Table 1) are calculated according to the contents of the wastes in nitrogen, phosphorus and potassium as well as the needs of common wheat on those elements which are 90-90-50 kg/ha. For each waste, four treatments were tested (100, 150, 200, 300%). Then a chemical fertilizer (CF) with similar percentages of treatments quoted above and the reference treatment (without fertilizer) are also applied to the common wheat with the same processing performed. Three repetitions are made for each treatment.

Table 2. Doses of bio-fertilizers for adding to the common wheat

Treatment (g/pot)/Waste	PP	AH	SW	CF
100%	80.50	262.50	14.00	3.00
150%	120.75	393.75	21.00	4.50
200%	161.00	525.00	28.00	6.00
300%	241.50	787.50	42.00	9.00

IV. Conclusion

The physicochemical analyzes showed clearly the richness of wastes selected by the major elements N, P and K and organic matter, which conveys them to an effective bio-fertilizers, those allows for good growth of the common wheat without harming the environmental quality as well as human health. Our results showed that almond hulls are characterized by their richness in phosphorus followed by nitrogen. For potato peels, they are rich in potassium and nitrogen. Concerning the shrimp waste, they are rich generally in nitrogen. According to those wastes contents in nitrogen, phosphorus and potassium as well as the needs of common wheat on these elements which are 90-90-50 kg/ha, the doses of organic wastes (g/pot) are calculated. The growth monitoring of the common wheat and the succession of this study will be completed in our next work.

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AUTHOR'S PROFILE

Prof. Fatima Boukhlifi , Professor in Department of Chemistry, member of Unit "Materials and Applied Catalysis", Faculty of Science, University Moulay Ismail, Meknes. researcher in the field of environment, I published a hundred publications and communications section in the water treatment and recycling solid waste in several areas. I studied the enhancement in the energetic field, materials and gricole. I have a patent in the valuations of eggshells to produce nanocomposite under No :MA 35225B1. Currently I continued my activities in several areas related to sustainable development.

Fatima Zahrae Mamouni, PhD Student, 4th year. Member of Units "Materials and Applied Catalysis", "Science of Water and Environmental Engineering" in Faculty of Science, University Moulay Ismail, Meknès and "Research Agronomy and Plant Physiology" in Regional Center for Agricultural Research, Meknès, Morocco.

Dr.RachidRazouk,Senior Chief Engineer, Researcher in Physiology Agro Fruit Trees and Olive Trees in Unit: "Research Agronomy and Plant Physiology", Regional Center for Agricultural Research, Meknès, Morocco.

Prof. AbdelhadiEl Ouali, Professor in Department of Geology, Faculty of Science, and Vice president of scientific research, cooperation and partnership, University Moulay Ismail, Morocco