PHYSICAL, CHEMICAL AND MINERALOGICAL CHARACTERISTICS OF COMMERCIALLY AVAILABLE EPPAWELA AND GAFSA ROCK PHOSPHATES

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ABSTRACT

Physical, chemical and mineralogical characteristics of commercially available Eppawela Rock Phosphate (ERP) was compared with a well known rock phosphate, Gafsa from Tunisia. The phosphate content of Eppawela material was low, around 16% and is two times lesser than Gafsa. Also, the extractable P in ERP was two times lesser than that of Gafsa, indicating its inferiority as a P source. A high amount of silica was present in the Eppawela material as an impurity and it therefore requires to ensure the quality control measures in a systematic way before it is marketed.

INTRODUCTION

Phosphorus is a key plant nutrient involved in wide range of plant processes and various tropical crops require large amount of P. Generally, average P_2O_5 absorbed to produce each ton of yield was reported as 2 Kg for tubers, 10 Kg for cereals, 14 Kg for grain legumes, 25 Kg for oil seeds and 38 Kg for tea (Tandon, 1987). Countries in the Asian region are reported to be sharing a bigger component of phosphate consumption. In relation to Sri Lankan agriculture, annual use of P_2O_5 by all crops is more than 30,000 MT for the year 1992. But, based on the present rate of growth in consumption of phosphate fertilizer, the P requirement could be achieved 41,000 MT in the year 2000 (Wijayathilaka, 1993).

Although, rock phosphate fertilizers imported from foreign countries are widely used to meet this demand, the locally available rock phosphate source, Eppawela, also play an important role as a P source. The Eppawela phosphate deposit is estimated at 60 million tones and current production is 30,000 tones per annum which could provide phosphate fertilizers for 5–10 centuries at the present rate of consumption (Jayawardhana, 1976 and 1989). Several compositional zones based on colour, texture, structure and phosphate minerals were identified in the .deposit (Dahanayake and Subasinghe, 1989). Laboratory analyses suggest variable P_2O_5 contents ranging from 30–40% and sometimes lower than that (Dissanayake, 1992;

IFS, 1990 and Sivasubramanium *et al*, 1981). During the current mining operations at Eppawela, the phosphate material is not differentiated and selected on any scientific or systematic basis. The ore is thus bulldozed and ground to a fine size and then use for tea (Krishnapillai, 1989), rubber (Yogaratnam, 1989) and coconut (Jayasekara, 1989) as a fertilizer. But, as a result of manufacturing procedure in this nature, phosphate materials of different compositions could be mixed and it would be affected quality of the marketed fertilizer. This study was therefore carried out to evaluate the physical, chemical and mineralogical properties of the commercially available ERP in comparison with high quality rock phosphate source, Gafsa from Tunisia.

MATERIALS AND METHODS

Chemical analysis

Total, citric acid soluble and water soluble P contents of each fertilizer were determined (The fertilizer and feeding stuffs regulations, 1973).

Particle size analysis

100g of rock phosphate fertilizer was passed through a series of sieves (800–125 microns) and the portion retained on each mesh size was weighed. Particle size was expressed as percentages on weight basis.

X-ray fluorescence (XRF)

XRF analyses were done on fertilizer fractions of different particle sizes except for the more courser fraction in addition to composite samples of both Gafsa and ERP. A 0.5–1.0 g of samples was ignited at 1000°C for 1 hour in a quartz crucible. Sub sample (0.196g) of the ignited rock phosphate was mixed with 0.196g of pure silica and 2.12g flux and heated at 1000°C for 20 min. and transferred immediately to a graphite disc. Cleaned cooled pellet washed with alcohol was subjected to x-ray analysis to determine the total composition of a range of elements by a philip PW 1404 model x-ray fluorescence spectrometer. Necessary correction was made for silica.

X-ray diffractrometry (XRD)

A hand ground sample of rock phosphate fertilizers prepared in Al holders was randomly oriented and the diffraction scans were made through the range 3–90^0 2α using phillips 2Kw diffractrometer with Fe filtered Co radiation. Peak positions were converted to ^{0}A values using the Brag equation in order to determine the minerals present in ERP.

RESULTS

Phosphorus contents in rock phosphates

The total phosphorus content of the commercially available ERP is nearly 2.5 times lesser than that of Gafsa rock phosphate. Also, extractability of phosphorus in Gafsa is three times higher than that of ERP (Table 1).

Table 1. *Extractability of phosphorus in rock phosphates*

	Total P_2O_5%	Citric acid soluble P_2O_5%*	Water soluble P_2O_5%*
Gafsa	27.5	33.9	-
Eppawela	11.5	10.0	0.04

* Both expressed as a percentage of the total phosphorus.

Particle size distribution

ERP contained higher proportion of finer particles and around 85% were smaller than 250 microns. But, Gafsa has only 80% of the similar size particles. Although, 75% of the particles in ERP were smaller than 200 microns, nearly 73% of particles in Gafsa were bigger than that size. However, both ERP and Gafsa contain similar quantities of very fine particles. The particle size distribution of rock phosphates is shown in figure 1.

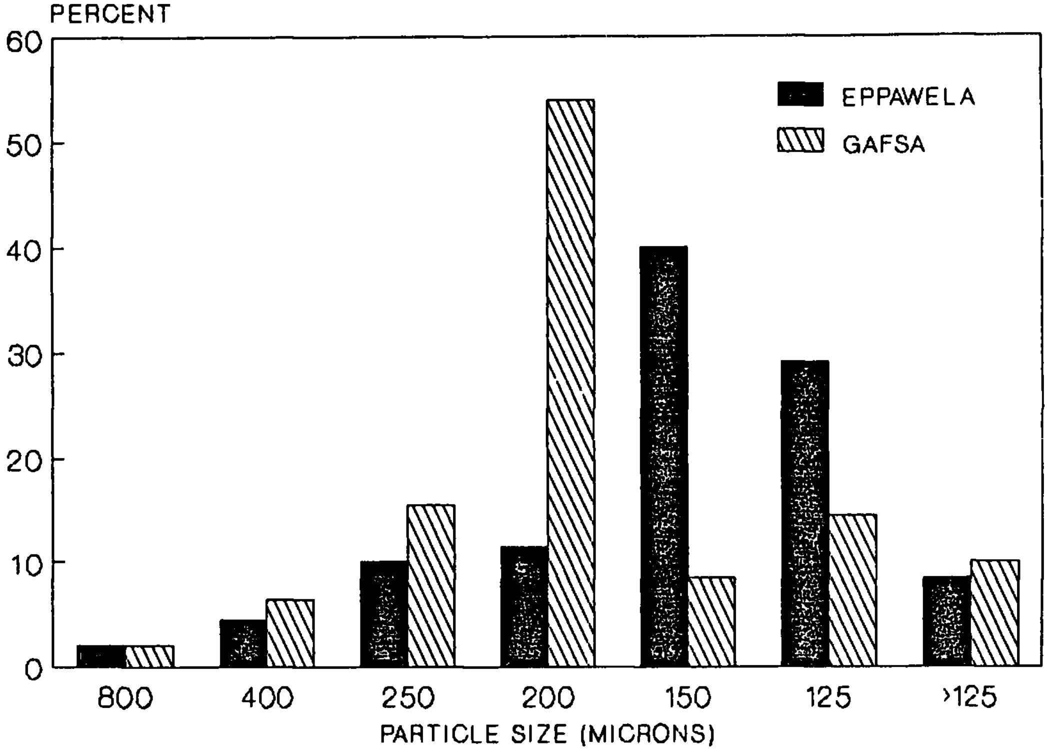


Fig. 1. Particle size distribution of rock phosphates

Chemical composition of rock phosphates

The chemical composition of rock phosphates are given in Table 2. The ERP was very low in phosphorus and the P_2O_5 content of Gafsa was almost double than that in ERP. ERP was contaminated with high amount of silica, iron and aluminium but, contained only low percentage of Ca. Nevertheless, Gafsa contained more than 50% of Ca and very low amount of Fe, Al and Si indicating that it is a valuable source of calcium phosphate. Also, the sulphur content in Gafsa is nearly 4 times higher than that in ERP. However, the concentrations of P, Fe, Al and Ca in ERP showed a tendency to increase with fineness of the material while Si contents appeared to decrease. But, this type of variation within particle size ranges were not observed for Gafsa and generally the chemical composition was similar irrespective of the particle size.

Table 2. *Chemical composition of Gafsa and Eppawela rock phosphates determined by XRF*

Size of the fertilizer fraction (Microns)	SiO_2%		TiO_2%		Al_2O_3%		Fe_2O_3%		MnO%		MgO%		CaO%		Na_2O%		K_2O%		P_2O_5%		SO_3%		Total	
	G	E	G	E	G	E	G	E	G	E	G	E	G	E	G	E	G	E	G	E	G	E	G	E
400	03.27	49.03	00.02	01.06	00.86	14.48	00.34	10.94	00.00	00.09	00.82	00.19	56.07	05.53	00.02	00.01	00.00	00.03	32.85	14.39	04.45	00.06	98.68	96.05
250	04.50	47.00	00.03	01.67	00.72	15.39	00.35	13.15	00.01	00.13	00.82	00.31	54.56	05.81	00.57	00.55	00.08	00.13	31.51	14.77	04.25	00.08	97.37	98.95
200	06.89	43.30	00.00	02.31	00.96	15.66	00.42	14.63	00.01	00.15	00.90	00.44	53.71	06.45	00.34	00.26	00.06	00.13	30.83	15.12	04.28	00.07	98.39	98.55
150	03.80	33.10	00.01	02.21	00.61	19.23	00.30	17.97	00.00	00.22	00.72	00.40	54.94	07.36	00.99	00.39	00.08	00.30	32.51	16.57	04.17	00.08	98.17	97.80
125	04.10	24.87	00.01	02.16	00.64	22.87	00.31	20.95	00.00	00.31	00.70	00.37	55.91	08.24	00.98	00.04	00.06	00.29	32.66	18.75	04.16	00.10	99.52	98.51
<125	05.41	26.70	00.02	02.28	00.82	20.68	00.37	19.69	00.00	00.27	00.72	00.40	54.24	07.65	00.21	00.24	00.02	00.30	31.80	17.29	04.37	00.07	97.98	95.41
Composit samples	07.40	34.60	00.06	02.14	01.18	18.88	00.50	17.34	00.01	00.23	01.39	00.37	52.82	07.03	00.65	00.55	00.16	00.27	28.64	16.43	04.30	00.09	97.10	97.95

G = Gafsa rock phosphate

E = Eppawela rock phosphate

Mineralogical composition of rock phosphate

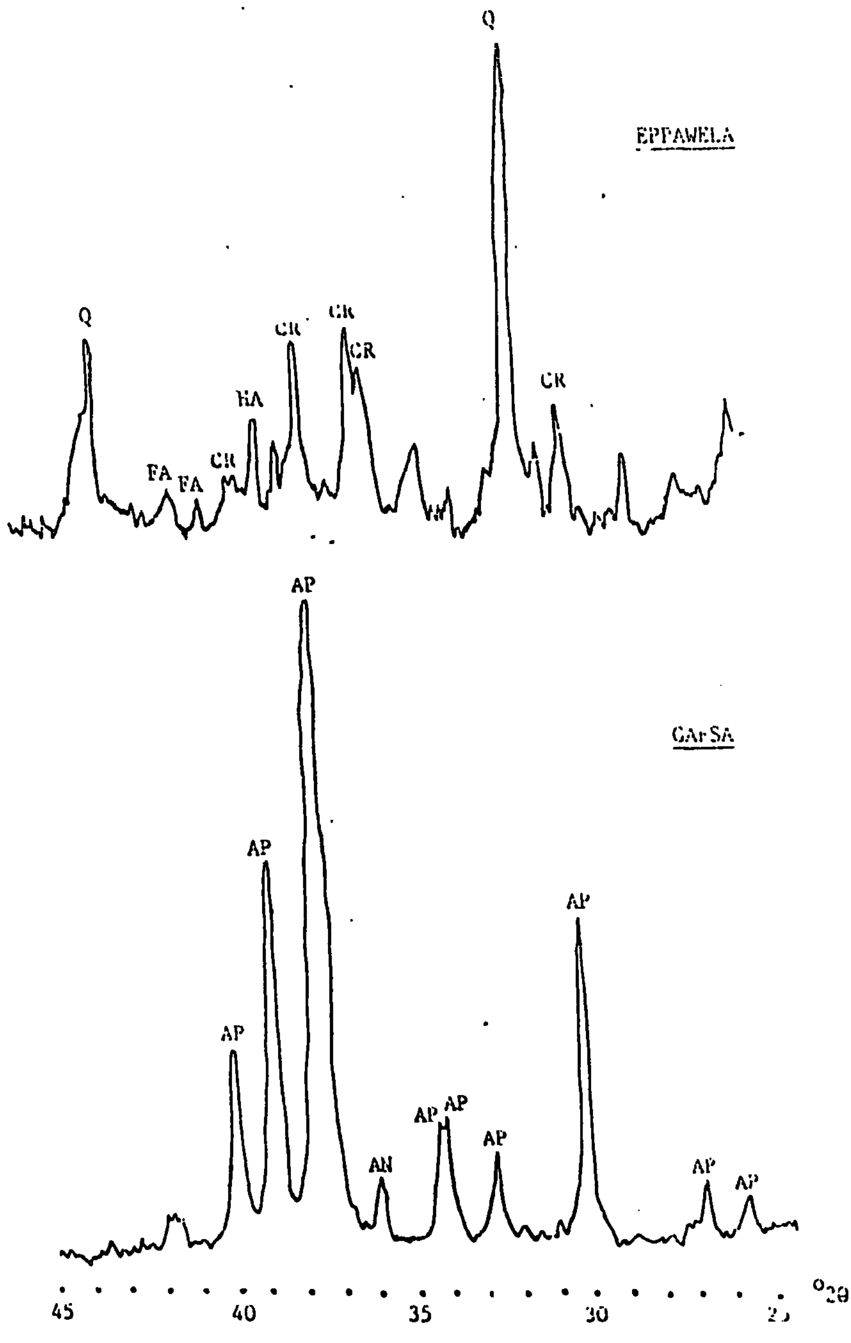
In the Eppawela material two main phosphate phases were identified. Many peaks due to Fluorapatite [$Ca_5F(PO_4)_3$] and Crandalite [$CaAl_3(PO_4)_2(OH)_5H_2O$] were present in the x-ray diffraction spectrum. The presence of quartz (SiO_2) and Hydroxyapatite was also observed in this material. This indicates that ERP is having a heterogenic nature in relation to its mineralogy. But, Gafsa contained many peaks mainly due to apatite [$Ca_5(PO_4)_3OH$] although few peaks were observed due to Marcasite (FeS_2) and Ancharite ($Fe.CaCO_3$). Gafsa can therefore be categorized as a homogeneous rock phosphate fertilizer in terms of its mineralogical composition (Fig. 2).

DISCUSSION

Based on the P_2O_5 content indicated by chemical and XRF analysis, Gafsa is clearly a good quality source of fertilizer phosphate. This agrees with earlier findings (Leon *et al*, 1986, Syres *et al*, 1986). According to the mineralogical analysis it is easily fallen into sedimentary rock phosphate group as material consisted mainly with apatite-calcium phosphate and this agrees with earlier findings (Mc Clellan 1978; Mc Clellan and Gremillion, 1980). Also, its P_2O_5 content is relatively uniform while the limited variation in particle size further indicated its qualitative value as a phosphate source.

Unlike Gafsa, ERP cannot be categorized as a homogeneous material in relation to its mineralogical composition. Although, it is categorized mainly as chlorofluroapatite (Jayawardena, 1976), it has other phosphate accessory minerals confirming earlier findings (Dahanayake, 1988, Dahanayake and Subasingha, 1989). Results of this study indicates that ERP mainly comprises of minerals containing Fe, Al, Ca and P.

XRF analysis indicated that ERP is a low quality product with a P_2O_5 content of around 16%. Although, this is not in line with some of the earlier findings which reported a 33% (Sivasubramanium *et al*, 1981) and 37% (Jayawardena, 1989) P_2O_5 content, but in agreement with other workers also who have reported low and highly variable P_2O_5 content among samples (IFS, 1990, Tennakone, 1988). The presence of accessory minerals in high amount in ERP as impurities confirmed the low quality of the material. Increase in the P_2O_5 content and decrease in silica content observed with decreased particle size suggests that the quality of the material could be improved to a certain extent if it is sieved to smaller size to remove most of the silicon particles. Particle size distribution of commercially available ERP showed that 85% of the



AP – APATITE
AN – ANCHARITE
Q – QUARTZ
FA – FLUROAPATITE
HA – HYDROXYAPATITE
CR – CRANDALITE

Fig. 2 X–ray diffraction traces of EPPAWELA and GAFSA rock phosphates particles are in this category. This would therefore improve the agronomic value of ERP as a P source because particle size has a great influence on rock phosphate dissolution (Howler and Wodruff, 1968, Syres *et al*, 1986). It should therefore be expected to ensure quality control measures in a systematic way before ERP is marketed.

The citric acid solubility of commercially available ERP is nearly 3 times lesser than that of Gafsa and therefore cannot be expected a higher reactivity in the soil as the citric acid solubility is known to be a better indication of the solubility of rock phosphates. Although, this again confirmed that it is fallen into the low grade of rock phosphate, its agronomic value would expected to be improved by mixing with other materials such as rubber factory effluent which is an acidic in nature.

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