Analysis of mineral content of iron sand deposit in Bontokanang Village and Tanjung Bayang Beach, South Sulawesi, Indonesia

Analysis of mineral content of iron sand deposit in Bontokanang Village and Tanjung Bayang Beach, South Sulawesi, Indonesia

V A Tiwow[1], M Arsyad[1], P Palloan[1] and M J Rampe[2]

[1]Department of Physics, Universitas Negeri Makassar, Kampus UNM Parangtambung, Makassar 90224, Indonesia
[2]Department of Chemistry, Universitas Negeri Manado, Kampus UNIMA, Tondano 95618, Indonesia

E-mail: vistatiwow@unm.ac.id

Abstract. Iron sand found in coastal areas in Sulawesi Selatan has not been optimally utilized. In this study, to analysis the mineral content of iron sand deposit, extraction, and characterization process were conducted. Iron sand was obtained from Bontokanang Village Takalar district and Tanjung Bayang Beach Makassar. Chemical composition analysis was performed of on samples by means of Tescan Vega3SB Scanning Electron Microscopy (SEM) coupled with Bruker Quantax System Energy Dispersive Spectroscopy (EDS). Analysis of the crystalline level and mineral composition were performed on the sample by using Rigaku MiniFlex II X-Ray Diffraction (XRD). The SEM-EDS analysis showed that iron sand in Bontokanang Village and Tanjung Bayang Beach was dominated by iron oxide (FeO) with concentration of 66,70 wt.% and 79,56 wt.%. The XRD analysis showed that iron sand from Bontokanang Village contains magnetite, chromium (VI) oxide, and aluminum oxide with concentrations of 59 wt.%, 30 wt.%, And 11 wt.%. While the iron sand from Tanjung Bayang Beach contains mineral iron silicon oxide and magnetite with concentrations of 77 wt.% And 23 wt.%. Iron sand deposit from Bontokanang Village and Tanjung Bayang Beach contain magnetite minerals that can be further explored and extracted as commercial minerals.

1. Introduction

Iron is an element which is naturally associated with other elements such as nickel, cobalt, manganese, chromium, molybdenum, and titanium [1]. Iron could be found in nature either in the form of iron ore [2–4] or iron sand [5]. Iron sand is abundant resources in Indonesia and could be found in beach, river and volcanic mountains.

The potential of iron in South Sulawesi is quite large. Iron ore potential can be found in District Bontocani. Its constituent minerals such as pyrite, hematite, magnetite, and also are found in minor amounts of molybdenum minerals [6,7]. While the potential of iron sand in South Sulawesi was located in the River Jeneberang, coastal of Bontokanang Village, Beach Tanjung Bayang, coastal of Jeneponto Regency and others that have not been optimally utilized.

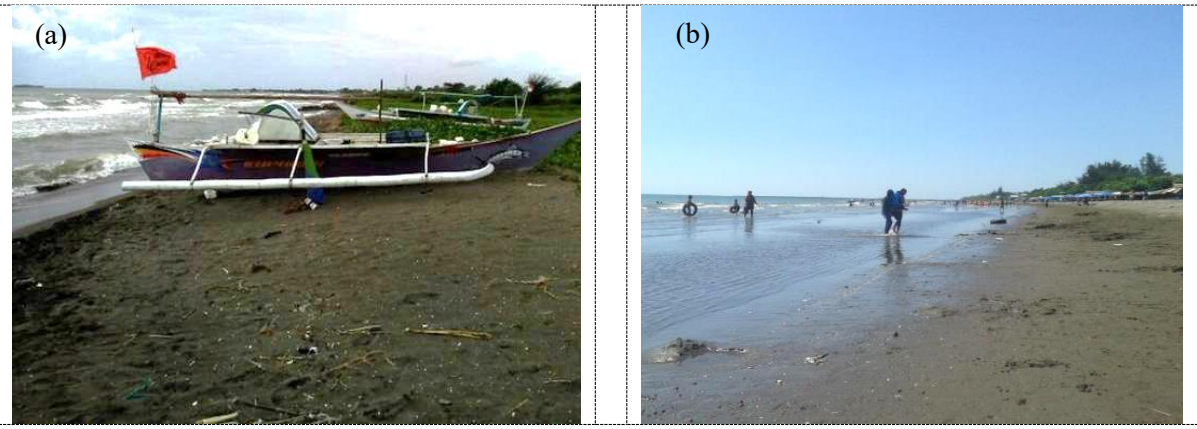

Figure 1. Iron sand deposit in (a) Bontokanang Village Takalar District dan (b) Tanjung Bayang Beach Makassar.

Iron sand contains magnetic minerals such as magnetite (Fe_3O_4), hematite (α-Fe_2O_3), maghemite (γ-Fe_2O_3), ilmenite ($FeTiO_3$), and titanomagnetite [8–10]. However, iron sand was not obtained the pure form in nature. There are some impurities such as Si, Ca, Mg, Al, etc. The magnetic minerals could be extracted or purified using magnetic separation as well as chemical separation [11,12]. Magnetic minerals can be used as the basic material for the production of toner [13], pigment [14], permanent magnet, and others metal industries.

Research on iron sand mineral content using X-Ray Fluorescence (XRF) and X-Ray Diffraction (XRD) method has been done on iron sand from Tapunggaya, Southeast Sulawesi dominated by Fe_2O_3 and followed by TiO_2, MgO, SiO_2 [15]. Analysis of mineral content iron sand by XRD method in Central Java from eight locations namely Srandil, Mungangharjo, Congot, Bayuran, Bandungharjo, Benteng Portugis, Pundenrejo, and Gunung Wungkal obtained magnetite and in minor composition hematite and ilmenit [16]. The similar study was also carried out at coastal areas at Syiah Kuala Beach, Banda Aceh. The iron sand was manually extracted with magnetic rod and characterized by XRD and XRF methods. The results showed that magnetic phase was dominant and the minor phase included TiO_2 and SiO_2 [17].

In this paper, analysis of the mineral content of iron sand deposit in Bontakanang village Takalar district and Tanjung Bayang beach Makassar Sulawesi Selatan will be reported. Scanning Electron Microscopy (SEM) method coupled with Energy Dispersive Spectroscopy (EDS) method was used for chemical composition analysis and XRD method for analysis of crystalline level and mineral composition.

2. Experimental

2.1. Materials

Iron sand was obtained in coastal areas of South Sulawesi, Indonesia, namely in Bontokanang Village Takalar District and Tanjung Bayang Beach Makassar, in the depth of 5 cm from the precipitate surface of iron sand representatively.
Some text.

2.2. Sample preparation

Iron sand was cleaned of dirt and washed with aquadest. Then dried at room temperature. Subsequently, the sample was weighed of 5 g, extracted manually using magnet rod [18–21] 40 times, and crushed using mortar for 6 hours.

2.3. Characterization using Scanning Electron Microscopy-Energy Dispersive Spectroscopy (SEM-EDS) method

The iron sand samples were characterized using Tescan Vega3SB SEM to investigate the morphology of material surfaces and particle distribution. This microscope works on the voltage of 20 kV using Back Scattered Electron (BSE) detector. This detector is sensitive to differences in chemical composition on the sample surface. Elemental testing with EDS was performed on a sample with Bruker Quantax System, where EDS Detector was equipped with the Esprit 1.9 software [22].

2.4. Characterization using X-Ray Diffraction (XRD)

Iron sand samples were characterized using X-Ray Diffraction (XRD) Rigaku MiniFlex II type. XRD measurements were done by powder method [22]. This XRD machine works on measurement conditions voltage of 30 kV, current of 15 mA, scan width of 0.02°, scan speed/duration time of 4°/min., and the scan range of 10°-70°. The qualitative analysis was done by search and match technique using PDXL2 software coupled with ICDD card (International Center for Diffraction Data) ver. 2011. Quantitative analysis of weight percent (wt.%) of crystalline phase was tested by RIR (Reference Intensity Ratio) method [6]. Furthermore, XRD measurements are compared with elemental measurement results using EDS.

3. Results and Discussion

Iron sand in Bontokanang Village, Takalar District and Tanjung Bayang Beach Makassar was obtained representatively, prepared sample and characterized by using SEM-EDS and XRD. Figure 1 shows that SEM image of iron sand samples from Bontokanang Village and Tanjung Bayang Beach were characterized using SEM Tescan Vega3SB type with 1000x magnification of the original size. Figure 1 shows that the surface of iron sand samples from Bontokanang Village and Tanjung Bayang Beach is gray with different levels caused by differences in the composition of the constituent elements. While the distribution of grains of sand was not uniform size caused by crushing techniques.

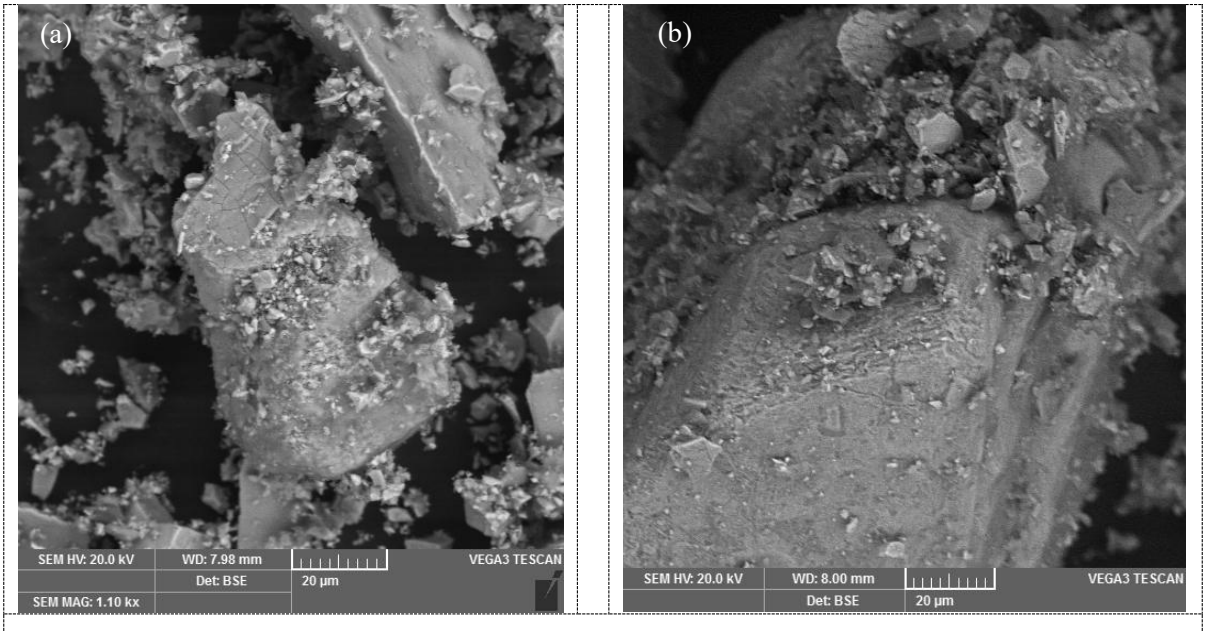

Figure 2. SEM image for iron sand samples from (a) Bontokanang Village Takalar District and (b) Tanjung Bayang Beach Makassar with the magnification of 1000x.

The chemical composition analysis obtained from EDS analysis of iron sand samples from Bontokanang Village Takalar District and Tanjung Bayang Beach Makassar is shown in Table 1. Based on EDS analysis, iron sand deposit from Bontokanang Village dominated by iron oxide (FeO) with a concentration of 66.70 wt.%, as well as iron sand from Tanjung Bayang Beach dominated by iron oxide (FeO) with concentration of 79.56 wt.%. Other compounds with minor compositions are titanium

(TiO_2), silicon (SiO_2), aluminum (Al_2O_3), magnesium (MgO), sodium (Na_2O), calcium (CaO), phosphorus (P_2O_5), and potassium (K_2O).

Table 1. The chemical composition of iron sand samples produced from two different places above.

	Mass percentage (wt%)	
Oxide	Bontokanang Village	Tanjung Bayang Beach
Sodium (Na_2O)	1.61	0.75
Magnesium (MgO)	3.60	0.92
Aluminium (Al_2O_3)	5.27	3.80
Silicon (SiO_2)	6.01	5.68
Phosphorus (P_2O_5)	0.85	-
Potassium (K_2O)	0.19	0.08
Calcium (CaO)	1.36	0.67
Titanium (TiO_2)	14.42	8.53
Iron (FeO)	66.70	79.56

The iron content is large enough caused by the extraction stage using magnet rod. The element of iron is attracted by the magnet rod so that the iron sand looks black [23–25]. This shows that iron sand has magnetic properties [26], namely ferromagnetic that can be pulled strongly by the magnet. Elements in minor compositions were obtained because it was also attracted to the iron when extracted. This shows that TiO_2, Al_2O_3, MgO, Na_2O, K_2O has paramagnetic properties. While SiO_2, CaO, P_2O_5 has diamagnetic properties. Table 1 also shows that these elements were derived from weathering of rocks at Lompobattang Volcano that is no longer active and carried by river currents to form alluvial deposits in the Jeneberang River area. At the lower reaches of the Jeneberang River, alluvial deposits were carried by the ocean currents and deposition occurs on the southern coast of Bantaeng District up to the west coast of Makassar.

XRD analysis results using XRD tool Rigaku MiniFlex II type operating on voltage of 30 kV and current of 15 mA. Measurements were made in the range of diffraction angle (2θ) of 10^o-70^o. Figure 2 shows that the diffraction pattern of iron sand samples from Bontokanang Village. In the samples were found three minerals with different compositions, namely magnetite (Fe_3O_4), chromium (VI) oxide (Cr_2O_3) and aluminum oxide (Al_2O_3). Figure 3 shows that iron silicon oxide ($Fe_{5.36}Si_{0.64}O_8$) and magnetite (Fe_3O_4) were found in iron sand samples from Tanjung Bayang Beach Makassar. The results showed that in both research sites magnetite minerals were obtained.

Mineral composition of iron sand samples based on XRD analysis with RIR method were shown in table 2. The magnetite mineral composition on the iron sand samples from Tanjung Bayang Beach is small. This is caused by more iron elements to form iron silicon oxide than magnetite. This result is in accordance with the SEM-EDS results obtained that the main element in the sample is iron. In addition, no mineral was obtained where the constituent elements are titanium. This is indicated by the crushing step carried out for 6 hours causing the minerals to be destroyed. Magnetite minerals (Fe_3O_4) are found in both research sites that can be further explored and extracted to obtain high purity magnetite, hence it can be used as commercial minerals.

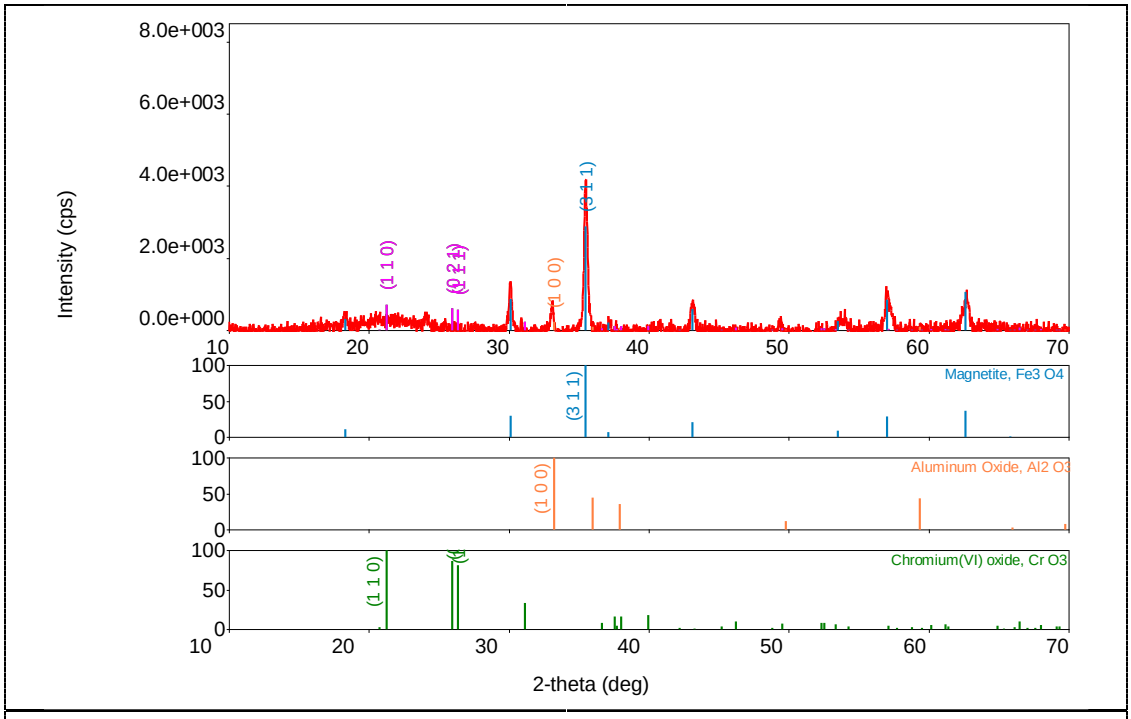

Figure 3. The diffraction pattern of iron sand from Bontokanang Village, Takalar District.

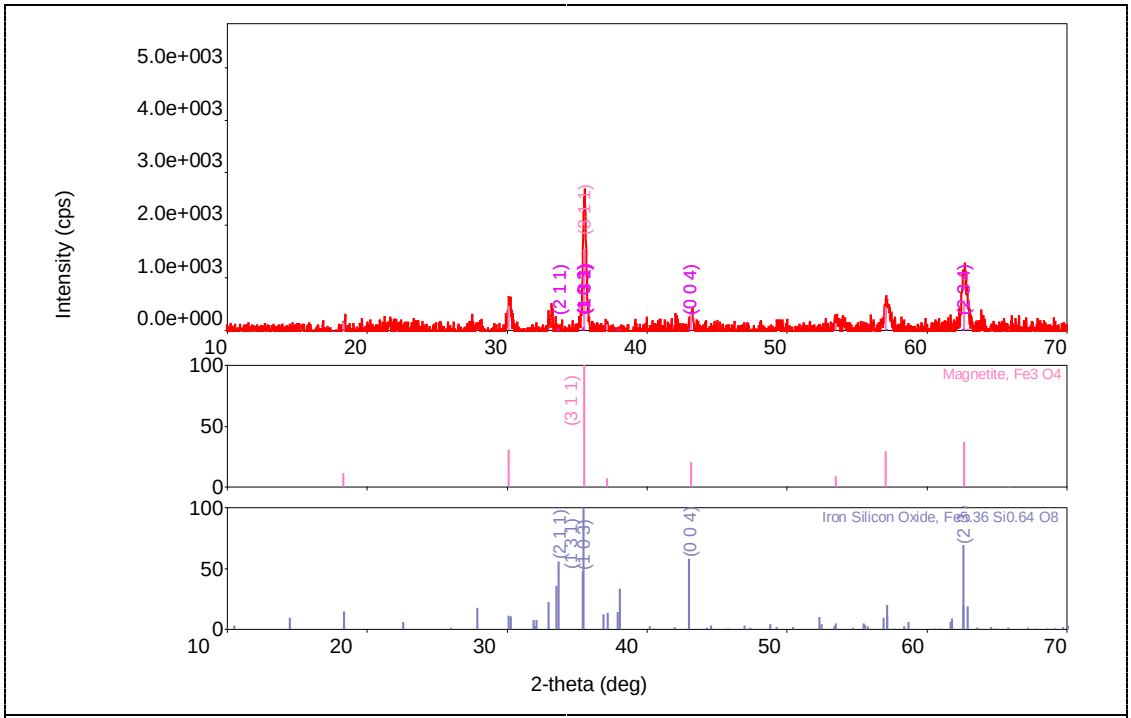

Figure 4. The diffraction pattern of iron sand from Tanjung Bayang Beach Makassar.

Table 2. Mineral composition of iron sand samples from Bontokanang Village and Tanjung Bayang Beach based on XRD analysis.

	Mass percentage (wt%)	
Mineral	Bonto Kanang Village	Tanjung Bayang Beach
Magnetite (Fe_3O_4)	59	23
Iron silicon oxide ($Fe_{5.36}Si_{0.64}O_8$)	-	77
Aluminum oxide (Al_2O_3)	30	-
Chromium (IV) oxide (Cr_2O_3)	11	-

4. Conclusion

Analysis result of the mineral content of iron sand deposit in Bontokanang Village Takalar District and Tanjung Bayang Beach Makassar showed that iron oxide (FeO) was the major element with the concentration of 66,70 wt.% and 79,56 wt.%, respectively The magnetite of 59 wt.%, Chromium (IV) oxide of 30 wt.%, and aluminum oxide of 11 wt.% were obtained in iron sand samples of Bontokanang Village, while iron silicon oxide of 77 wt.% and magnetite of 23 wt.% were obtained in iron sand samples from Tanjung Bayang Beach. From both locations, the magnetite mineral was found to be potential as an industrial raw material. Therefore, further research is required to purify it.

Acknowledgements

We would like to thank Muhammad Rizal Fahlepy for helping the preparation iron sand samples. Acknowledgments also were given to the operator of Microstructural Laboratory of Department of Physics, Universitas Negeri Makassar, Nurfadillah, S.Si., Syamsidar, S.Si., and Kharisma Noer Afifah, S.Si. in assisting data analysis.

References

[1] Kramadibrata S 2013 *Procedia Earth Planet. Sci.* **6** 6–7
[2] Muwanguzi A J B, Karasev A V, Byaruhanga J K and Jonsson P G 2012 *ISRN Mater. Sci.* **2012** 1–9
[3] Rudmin M, Reva I, Gunko A, Mazurov A and Abramova R 2015 *IOP Conf. Ser. Earth Environ. Sci.* **27** 12026
[4] Kiptarus J J, Muumbo A M, Makokha A B and Kimutai S K 2015 *Int. J. Min. Eng. Miner. Process.* **4** 8–17
[5] Vasudevan G 2016 *Proc. the 3rd Int. Conf. Civil, Biol. Environ. Eng.* 10–13
[6] Subaer, Nurhayati, Nurhasmi and Nurfadillah 2014 *Indones. J. Appl. Phys.* **4** 134–141
[7] Haris A, Amin B D, Yusuf A M and Nurhasmi 2014 *J. Sains dan Pendidik. Fis.* **10** 263–268
[8] Findorak R, Froehlichova M and Legemza J 2014 *Metalurgija* **53** 9–12
[9] Nugraha P A, Sari S P, Hidayati W N, Dewi C R and Kusuma D Y 2016 *Proc. The 2016 Conf. on Fundamental and Applied Science for Advanced Technology (Yogyakarta)* **1746** (New York: AIP Conf. Proc.) p 20028
[10] Bassez M-P 2017 *Procedia Earth Planet. Sci.* **17** 492–5
[11] Sunaryono, Taufiq A, Mashuri, Pratapa S, Zainuri M, Triwikantoro and Darminto 2015 *Mater.*

Sci. Forum **827** 229–34
[12] Setiadi E A, Sebayang P, Ginting M, Sari A Y, Kurniawan C, Saragih C S and Simamora P 2016 *J. Phys. Conf. Ser.* **776** 12020
[13] Ataeefard M, Ghasemi E and Ebadi M 2014 *Sci. World J.* **2014** 706367
[14] Mufti N, Atma T, Fuad A and Sutadji E 2014 *Proc. the 3rd Int. Conf. on Theoretical and Applied Physics (Malang)* **1617** (New York: AIP Conf. Proc.) p 165–169
[15] Nurdin M, Watoni A H and Abdillah N 2016 *Int. J. ChemTech Res.* **9** 483–91
[16] Yulianto A, Bijaksana S, Loeksmanto W, Sekaran J R and Pati G 2003 *Indones. J. Phys.* **14** 1–4
[17] Jalil Z, Rahwanto A, Mustanir, Akhyar and Handoko E 2017 *Proc. the 2nd Int. Symp. on Current Progress in Mathematics and Sciences (Depok)* **1862** (New York: AIP Conf. Proc.) 30023-1 030023–4
[18] McCubbin D, Leonard K S, Young A K, Maher B A and Bennett S 2004 *J. Environ. Radioact.* **77** 111–131
[19] Yulianto A, Sulhadi, Azis A L I and Dayati E 2013 *Malaysian J. Fundam. Appl.* **9** 211–215
[20] Rahmawati R, Melati A, Taufiq A, Sunaryono, Diantoro M, Yuliarto B, Suyatman S, Nugraha N and Kurniadi D 2017 *IOP Conf. Ser. Mater. Sci. Eng.* **202** 12013
[21] Rahmawati R, Permana M G, Harison B, Nugraha, Yuliarto B, Suyatman and Kurniadi D 2017 *Procedia Eng.* **170** 55–59
[22] Subaer 2015 *Pengantar Fisika Geopolimer* (Jakarta: Direktorat Jenderal Pendidikan Tinggi)
[23] Ige A and Rehren T 2003 *Iams* **23** 15–20
[24] Fouda M F R, Amin R S, Saleh H I, Labib A A and Mousa H A 2010 *Aust. J. Basic Appl. Sci.* **4** 4540–4553
[25] Chaussard E and Kerosky S 2016 *Remote Sens.* **8** 100
[26] Sehah and Raharjo S A 2017 *J. Penelit. Fis. Apl.* **7** 79–88.