การใช้เทคนิคไอออนโครมาโทกราฟีวิเคราะห์ปริมาณแร่ธาตุที่สะสมในไลเคนเพื่อเป็นดัชนีทางชีวภาพในการเฝ้าติดตามคุณภาพอากาศบริเวณรามคำแหงในกรุงเทพมหานคร

ANALYSIS OF ELEMENTAL ACCUMULATION IN LICHEN BY USING ION CHROMATOGRAPHY FOR BIOMONITORING OF AIR QUALITY AT RAMKHAMHAENG AREA IN BANGKOK

กิตติยา แซ่เจี่ย*[1], ชูติมา ศรีวิบูลย์[1], กัณฑรีย์ บุญประกอบ[2]

Kittiya Saejia, Chutima Sriviboon, Kansri Boonpragob

*, 1, Department of Chemistry, Faculty of Science, Ramkhamhaeng University, Bangkok 10240, Thailand; e-mail address: chutima@ram1.ru.ac.th

2, Department of Biology, Faculty of Science, Ramkhamhaeng University, Bangkok 10240, Thailand; e-mail address: kansri@ram1.ru.ac.th

บทคัดย่อ: ได้นำเทคนิคไอออนโครมาโทกราฟีมาใช้ในการวิเคราะห์ธาตุ 26 ชนิด (F^-, Cl^-, NO_2^-, Br^-, NO_3^-, PO_4^{3-}, SO_4^{2-}, $C_2O_4^{2-}$, Li^+, Na^+, NH_4^+, K^+, Rb^+, Cs^+, Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Cu^{2+}, Ni^{2+}, Zn^{2+}, Co^{2+}, Mn^{2+}, Cd^{2+}, Pb^{2+} และ Fe^{3+}) ในไลเคน โดยทำการเก็บตัวอย่างไลเคน *Parmotrema tinctorum* มาพร้อมกับกิ่งไม้ที่ไลเคนเกาะ (ต้นไทร) จากอุทยานแห่งชาติเขาใหญ่ ประเทศไทย ซึ่งจัดเป็นพื้นที่ปราศจากมลพิษ ทำการย้ายปลูกมาชุมชนเมือง ณ พื้นที่ตรวจวัด 5 จุด บริเวณรามคำแหง ซึ่งจัดเป็นพื้นที่มีมลพิษโดยเก็บตัวอย่าง 2 ฤดู คือฤดูฝน เริ่มต้นเก็บเดือน สิงหาคม 2547 และฤดูแล้ง เริ่มต้นเก็บเดือน ธันวาคม 2547 ระยะเวลาในการศึกษาคือ 6 เดือนสำหรับฤดูฝน และ 3.5 เดือนสำหรับฤดูแล้ง ผลจากการศึกษาโดยใช้ไลเคนเป็นตัวตรวจวัดคุณภาพอากาศพบว่า F^-, Cl^-, NO_3^-, PO_4^{3-}, SO_4^{2-}, NH_4^+ มีการสะสมมากขึ้นเมื่อเวลาเพิ่มขึ้นทั้งในฤดูฝนและฤดูแล้ง โดยฤดูแล้งมีการสะสมมากกว่าฤดูฝน ยกเว้น $C_2O_4^{2-}$ ที่ไม่มีการสะสมในฤดูแล้ง แสดงว่าการสะสมของธาตุเหล่านี้มีทั้งแบบ dry deposition และ wet deposition ณ พื้นที่รามคำแหง สำหรับในฤดูฝนปริมาณของ Li^+, Na^+, K^+, Rb^+, Mg^{2+}, Ca^{2+}, Ba^{2+}, Cu^{2+}, Ni^{2+}, Zn^{2+}, Mn^{2+}, Fe^{3+} คงที่ ซึ่งแสดงว่าไม่มีการสะสมของธาตุเหล่านี้ ส่วนในฤดูแล้งพบว่า Na^+, Rb^+, Ba^{2+}, Cu^{2+}, Zn^{2+} Mn^{2+}, Fe^{3+} มีปริมาณคงที่ แต่ Li^+, K^+, Mg^{2+}, Ca^{2+} มีแนวโน้มลดลงเมื่อเวลาเพิ่มขึ้น

Abstract: The twenty-six elements (F^-, Cl^-, NO_2^-, Br^-, NO_3^-, PO_4^{3-}, SO_4^{2-}, $C_2O_4^{2-}$, Li^+, Na^+, NH_4^+, K^+, Rb^+, Cs^+, Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Cu^{2+}, Ni^{2+}, Zn^{2+}, Co^{2+}, Mn^{2+}, Cd^{2+}, Pb^{2+}, and Fe^{3+}) in lichen were analyzed by using Ion chromatography. Lichen *Parmotrema tinctorum* attached on branches of host tree, *Ficus sp.*, from the unpolluted site at KhaoYai National Park, Thailand, were collected and transplanted to 5 biomonitoring sites at Ramkhamhaeng area in two seasons: wet season started in August, 2004 and dry season started in December, 2004. The exposure times in wet and dry season lasted for 6 and 3.5 months, respectively. The results indicated increasing accumulation of F^-, Cl^-, NO_3^-, PO_4^{3-}, SO_4^{2-} and NH_4^+ with time in both seasons, except $C_2O_4^{2-}$ was constant in dry season. The accumulation during dry season was higher than wet season. It indicated significant accumulation of these elements as dry and wet deposition at Ramkhamhaeng area. Li^+, Na^+, K^+, Rb^+, Mg^{2+}, Ca^{2+}, Ba^{2+}, Cu^{2+}, Ni^{2+}, Zn^{2+}, Mn^{2+} and Fe^{3+} were constant in wet season, indicated that no accumulation of these elements occurred. In dry season Na^+, Rb^+, Ba^{2+}, Cu^{2+}, Zn^{2+}, Mn^{2+} and Fe^{3+} were constant, but Li^+, K^+, Mg^{2+} and Ca^{2+} were decreased with increasing time.

Introduction: Biological monitoring can be very efficiently used as an early warning system to detect environmental changes. It has advantage over expensive equipment because many traditional studies on atmospheric pollutants have been limited by high cost and the difficulty of carrying out extensive sampling. Lichens have been used extensively as biomonitor and bioindicator of air pollution for a long time. According to lichens absorbed nutrients directly from atmospheric water, they are more susceptible to air pollutants than plants and animals that have better protective covering and selectively obtain their nutrients from the soil or from eating other organisms. Water and gas are exchanged over the entire lichens thallus. Because they lack roots, lichens do not have access to soil nutrient pools and must depend on deposition. Thus, their tissue content largely reflects atmospheric sources of nutrients and contaminants. The advantages of using transplanted lichen to polluted site is apply in several areas to get the basic information of elemental accumulation in lichens at the present for assessing air quality and for monitoring changes in the future. The elements accumulated in lichen cause from air pollution that can indicate air quality. In this research, ion chromatography (IC) was used for determination all of anions, cations, and heavy metals. This technique is generally easy to use, provide rapid turn around time for analysis, and can analyze multiple ions of each group at the same time.

Methodology: The lichen *Parmotrema tinctorum* was used as biomonitoring material of air quality in Bangkok Metropolitan area at Ramkhamhaeng University campus. The study consisted of wet season during August, 2004 – February, 2005 and dry season during December, 2004 – April, 2005. Lichen was transplanted from the unpolluted site at KhaoYai National Park to the polluted site at Ramkhamhaeng university area. The elements were analyzed by using ion chromatography and calculated in dry weight basis of lichen. In each season, the elements in lichen were analyzed at the initial time and at time intervals after exposure. At the initial time, bark of the host tree, *Ficus sp*., was also analyzed for elements to compare with those found in lichens. Each analysis, lichens were randomly collected from all five sites. In wet season lichens were analyzed after exposure time of 0.5, 1, 2, 3, and 6 months, and in dry season after 1, 2, 3, and 3.5 months. Finally the elements in lichen at unpolluted site collected in June, 2005 were analyzed to compare with transplantation lichen.

Results, Discussion and Conclusion: Comparison of element contents in the lichen *P. tinctorum* with *Ficus sp.* bark in both seasons revealed that Mg^{2+}, Ca^{2+}, Zn^{2+} and Fe^{3+} in lichen were higher than bark, whilst F^-, NH_4^+, K^+, Mg^{2+}, Ca^{2+} and Ba^{2+} in lichen were less than bark. Twenty-six elements accumulated in lichens after 6 months exposure time in the wet season and 3.5 months in the dry season at the polluted biomonitoring site can be concluded: Firstly, the concentrations of F^-, Cl^-, NO_3^-, PO_4^{3-}, SO_4^{2-} and NH_4^+ increased with time in both seasons (as Fig 1, 2) while $C_2O_4^{2-}$ only increased in the wet season. The results also showed that deposited in the dry season was higher than the wet season, and accumulation of Cl^-, NO_3^-, SO_4^{2-} and NH_4^+ were higher than F^-, PO_4^{3-} and $C_2O_4^{2-}$. (Higher accumulation of these elements in the polluted site higher causes by different in air quality in both areas.) In dry season, the concentrations of these elements after 2 months exposure decreased that cause form rainfall effect. Secondly, the concentrations of Li^+, Na^+, K^+, Rb^+, Mg^{2+}, Ca^{2+}, Ba^{2+}, Cu^{2+}, Ni^{2+}, Zn^{2+}, Mn^{2+} and Fe^{3+} were constant after exposure during the wet season while the concentrations of Li^+, K^+, Mg^{2+} and Ca^{2+} decreased during the dry season. It indicated that no accumulation of these elements at the polluted site. Thirdly, NO_2^-, Cs^+, Sr^{2+}, Ni^{2+}, Co^{2+}, Pb^{2+}, and Cd^{2+} in the dry season could not be detected before and after exposure, while Br^- could be found occasionally. In wet season, NO_2^-, Co^{2+},

Pb^{2+}, and Cd^{2+} could not be detected while Br^{-}, Cs^{+}, and Sr^{2+} are trace elements that were sparsely found. In this research, it was found that elementals accumulation in lichens at KhaoYai National Park lower than urban area that indicate air quality at KhaoYai National Park better than urban area (Bangkok).The basic information of elementals accumulation in lichens at the present air pollution in urban area can be used to compare elementals deposition in lichen at the future to indicate air quality change.

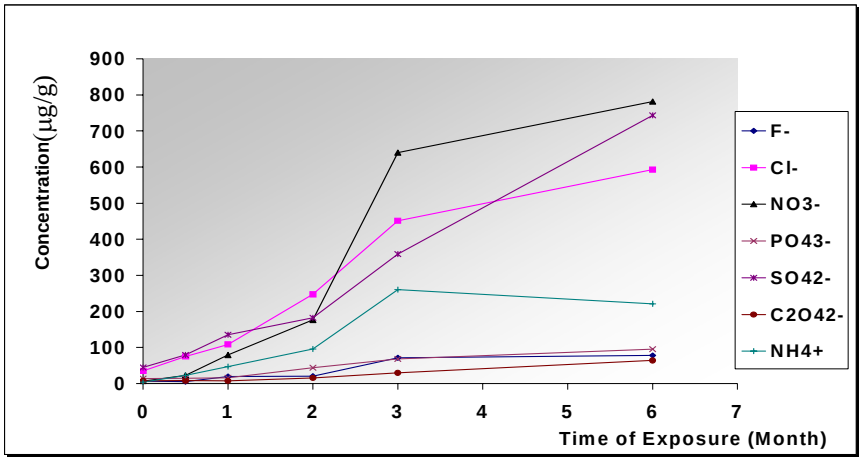

Fig (1) The Amounts of Element Accumulated in the Lichen *P. tinctorum* after Transplanted from KhaoYai National Park to Ramkhamhaeng Area in the Wet Season during August, 2004-February, 2005.

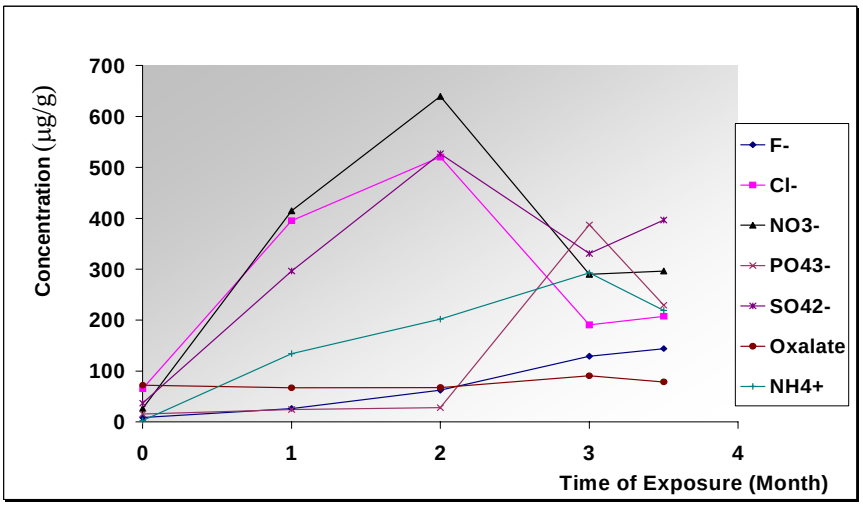

Fig (2) The Amounts of Element Accumulated in the Lichen *P. tinctorum* after Transplanted from KhaoYai National Park to Ramkhamhaeng Area in the Dry Season during December, 2004-April, 2005

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