Concentrations of trace elements in rice and their dietary exposure by the population of the volcanic ecosystem of Asembagus, East Java

A comparison between irrigation with unpolluted water and natural acid surface water

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For God, I give the glory.

I dedicate my thesis for

My beloved Fandi and to Alex and Budi, as my supervisor.

I'm very thankful

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Hanya dekat padamu Bapa, jiwakupun tenang
Engkau menerimaku, dengan sepenuhnya
Walau dunia melihat rupa, namun kau memandangku
Sampai kedalaman hatiku……

Tuhan inilah yang kumau, kau mengenal hatiku
Jauh melebihi semua yang terdekat sekalipun
Tuhan inilah yang kutahu, kau menjaga hatiku
Supaya kehidupan memancar senantiasa

SUMMARY

Rice is the main staple food of 40% of the world population and the main food throughout South-East Asia, especially Indonesia. When polluted water is used for irrigation on paddy soils, toxic substances may be incorporated into plant parts. These toxic substances may thus enter the food chain and possibly affect the health of animals and humans. The objective of this study were (1) to determine the quality of rice irrigated with polluted or clean water in relation to their metal concentrations and (2) to make a Risk Assessment for people in Asembagus (East Java, Indonesia) who consume rice from this area. Samples were collected from five polluted rice fields (irrigated with water polluted by the Ijen Crater Lake) and five non-polluted rice fields (irrigated with water from another source). Whole plants were collected from one polluted location and from one non-polluted location. The plants were cleaned with tap water and aquades and divided into three parts: roots, leaves and stems and grains. ICP-MS was used to measure concentration of Al, B, Cd, Cu; Mn and Zn. Chemical compositions of rice grain were measured in ash, carbohydrate, crude fiber, lipid, protein, water and dry weight of individual rice grain according to AOAC (1995). In general the accumulation of metals can be ranked in the order of roots; stems, leaves; grains only B showed a clear different ranking of accumulation: stem and leaves; roots; grains. Overall, concentrations of nutrient in polluted rice were significantly lower than those of unpolluted rice except for lipid and protein. Positive correlation was found between B and ash; B and carbohydrate; Zn and protein; Zn and dry weight of rice grain; Zn and Cd; Zn and Cu; and also Zn and Mn. High contribution (>10%) to the total daily intake (DI) of Cd, Cu, Mn and Zn was originated from polluted rice. High contributions of the same metals were also provided by consumption of unpolluted rice, except for Cd. Consumption of vegetables resulted in high contributions to total DI of all metals. Additionally, consumption of other foodstuffs and materials in the diet also provided high contributions of certain metals. In terms of total diet, consumption of food from areas of polluted and unpolluted irrigation did not result in different values of hazard quotients (HQs) for all metals. HQs for Mn were strikingly high ($\geq$0.8), both in polluted and unpolluted areas. However, when calculated exclusively based on rice consumption, the values of HQ in polluted areas were much higher than those in unpolluted areas, especially for Cd.

RINGKASAN

Beras merupakan makanan pokok dari 40% populasi dunia dan makanan utama Asia Tenggara, khususnya Indonesia. Bila air yang telah terpolusi digunakan untuk irigasi tanaman padi, maka substansi beracun dapat masuk ke bagian tanaman. Substansi beracun dapat masuk ke rantai makanan and sangat mungkin berpengaruh terhadap kesehatan hewan dan manusia. Tujuan penelitian ini adalah (1) mengetahui kualitas padi yang diairi dengan air yang telah terpolusi dan air yang tidak terpolusi dan hubungannya dengan konsentrasi logam (2)membuat *Risk Assessment* untuk penduduk di Asembagus (Jawa Timur, Indonesia) yang mengkonsumsi padi dari tempat ini. Sampel biji berasal dari lima sawah yang terpolusi (diairi dengan air yang terpolusi oleh Kawah Ijen) dan lima sawah yang tak terpolusi (dialiri gengan air dari sumber lain). Tanaman padi yang lengkap diambil dari satu lokasi yang terpolusi and satu dari lokasi yang tidak terpolusi. Tanaman dibersihkan dengan air biasa and aquades and dibagi menjadi tiga bagian: akar, daun dan batang, dan biji. Pengukuran kandungan logam Al, B, Cd, J, Mn dan ZN menggunakan ICP-MS. Analisa komposisi kimia biji padi eliputi abu, karbohidrat, serat kasar, lemak, protein, air dan berat kering biji padi rdasarkan AOAC (1995). Secara umum akumulasi logam terdapat pada: akar>batang dan daun>biji hanya B yang mempunyai akumulasi berbeda: batang dan daun> akar> biji. Semua konsentrasi nutrient biji padi yang terpolusi lebih rendah daripada padi yang tak terpolusi kecuali lemak dan protein. Korelasi positif ditemukan antara B dan abu, B dan karbohidrat, Zn dan protein, Zn dan berat kering biji, Zn dan Cd, Zn dan Cu, juga Zn dan Mn. Kontribusi tinggi (>10%) terhadap total *daily intake* (DI) Cd, Cu, Mn dan Zn berasal dari padi yang terpolusi. Konsumsi beras yang tak terpolusi dari beberapa logam juga mempunyai kontribusi yang tinggi terhadap DI, kecuali Cd. Konsumsi dari sayuran mempunyai kontribusi yang tinggi terhadap semua logam. Disamping itu, konsumsi bahan pangan dan bahan yang lain dalam makanan juga mempunyai kontribusi yang tinggi terhadap beberapa logam. Konsumsi makanan dari area terpolusi dan yang tak terpolusi tidak menunjukkan perbedaan dalam *hazard quotient* (HQs) semua logam. HQs Mn area terpolusi dan area tak terpolusi mencolok lebih tinggi (≥0.8). Berdasarkan tingkat konsumsi padi, HQ area terpolusi lebih tinggi daripada area tak terpolusi, khususnya Cd.

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Semarang

Inge Chandra Dewi

LIST OF CONTENTS

LIST OF TABLES

page

LIST OF ILLUSTRATIONS

page