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SUMMARY

THE USE OF BIOACCUMULATION IN WEAVER FEATHERS AND BIOMARKERS AS BIOINDICATORS OF METAL CONTAMINATION

Keywords: metals, feathers, bioaccumulation, bioindicators, biomarkers

The recognition of the occurrence, importance and effects of contaminants on food chains and ecosystems has led to the development of biomonitoring programmes that use indicator species to estimate the levels in other parts of the ecosystem. There has been an increased awareness of potential pollution of ecosystems in Gauteng, South Africa, because of increased formal and informal urbanization, industrialization and mining activities. It is essential to obtain clear indications of metal pollution cause-effect relationships at ecosystem level in order to carry out effective management of these ecosystems. The objective was to investigate the application of an ecotoxicologically-based investigation of metals in selected bird species as bioindicators of metal pollution of ecosystems in Gauteng.

Three passerine species were used, the Southern Masked Weaver (*Ploceus velatus*), the Red Bishop (*Euplectes orix*) and the Red-billed Quelea (*Quelea quelea*). The sites were selected to represent a theoretical pollution gradient from severely contaminated wetlands in the Vaal Triangle, to moderately contaminated wetlands in the Witwatersrand and Pretoria. A nature reserve in North West Province was chosen as reference site. The sites were Rietvlei in Tshwane, Roodekrans and Olifantsvlei in Johannesburg, Holfontein in the Vaal Triangle and Barberspan in North West Province. Two sampling surveys were carried out, one in 2002 and one in 2005. Feathers were collected for metal analyses. Blood samples were collected for biomarker (oxidative stress and DNA damage) and haematological analyses. The samples were digested using the microwave destruction technique. The metal analyses were carried out using ICP-MS. Oxidative stress enzymes (reduced glutathione content and catalase activity) were analysed in plasma samples and DNA damage was evaluated in red blood cells using the average base-pair length

comparison technique. Haematological studies were done on the blood samples. The results were compared between the sites and surveys. The levels of stress correlated well with the levels of metals in the feathers. Sites with higher metal levels had higher levels of organism stress. Thus the study showed that the feathers can indeed be used in biomonitoring.

Internationally there is a trend to incorporate Ecological Quality Objectives (EcoQOs) into legislation, especially when dealing with metal contamination. Within the framework of EcoQOs developed for birds the monitoring of contaminants forms a specific category of EcoQOs. However, due to a lack of available data, Reference and Target Levels still need to be set. The development of EcoQOs is especially important at this stage in South Africa. The recently promulgated National Biodiversity Act (10 of 2004) specifically provides for the preparation of conservation plans for identified ecosystems that are important because of their goods and services that they provide. Since there is no management tool available at present to develop a suitable management plan, the setting of EcoQOs that are in line with international standards and practices will be of immeasurable value to implementing the Act. Feathers from museum specimens were used to determine the Reference Levels for the various metals in the feathers. The Target Levels were calculated from the Reference Levels. These were compared to the Current Levels and the EcoQOs were determined for the metal levels in the feathers in weaver in Gauteng, South Africa.

OPSOMMING

DIE GEBRUIK VAN BIOAKKUMULERING IN WEWERVERE EN BIOMERKERS AS BIO-INDIKATORS VAN METALKONTAMINASIE

Sleutelwoorde: metale, vere, bioakkumulering, bio-indikators, biomerkers

Die erkenning van die voorkoms, belangrikheid en effek wat besoedelstowwe op voedeselkettings en ekosisteme het, het gelei tot die ontwikkeling van biomoniterings-programme wat indikatorspesies gebruik om die vlakke in ander dele van die ekosisteem te bereken. Daar is ‘n toenemende bewuswording van moontlike besoedeling in die ekosisteme in Gauteng, Suid-Afrika, as gevolg van toenemende formele en informele verstedeliking, meer industrieë en mynbouaktiwiteite. Dit is noodsaaklik om duidelike aanduidings van oorsaak-effek verhoudings rakende metaalbesoedeling op ekosisteemvlak te verkry vir die effektiewe bestuur van hierdie ekosisteme. Die doelwit was om ondersoek na die toepassing van ‘n ekotoksikologies-gebaseerde ondersoek van metale in geselekteerde voëlspesies as bio-indikators van metaalbesoedeling van ekosisteme in Gauteng in te stel.

Drie sangvoëlspesies is gebruik, naamlik die Swartkeelgeelvink (*Ploceus velatus*), die Rooivink (*Euplectes orix*) en die Rooibekkwelea (*Quelea quelea*). Die lokaliteite is gekies om ’n teoretiese besoedelingsgradiënt te verteenwoordig, van die swaar besoedelde vleilande in die Vaaldriehoek, tot die gematig besoedelde vleilande in die Witwatersrand en Pretoria. ‘n Natuurreservaat in Noordwes Provinsie is gekies as ‘n verwysingslokaliteit. Die lokaliteite was Rietvlei in Tshwane, Roodekrans en Olifantsvlei in Johannesburg, Holfontein in die Vaaldriehoek en Barberspan in Noordwes. Twee monsteropnames is gedoen, een in 2002 en een in 2005. Vere is versamel vir metaalanalise. Bloedmonsters is versamel vir biomerker- (oksidatiewe stres en DNA-skade) en hematologiese analises. Die monsters is verteer deur middel van die mikrogolfvernietigingsmetode en metaalanalise is uitgevoer deur van IGP-MS gebruik te maak. Oksidatiewe stresensieme (gereduseerde glutatiooninhoud en katalase-aktiwiteit) is geanaliseer in plasmamonsters en DNA-skade is geëvalueer in

rooibloedselle deur van die gemiddelde basispaar lengte metode gebruik te maak. Hematologiese studies is ook op die bloedmonsters gedoen. Die resultate is vergelyk tussen die lokaliteite en die proefnemings. Die stresvlakke het goed gekorreleer met die metaalvlakke in die vere. Lokaliteite met hoër metaalvlakke het hoër vlakke van organismestres gehad. Die studie het dus getoon dat vere inderdaad gebruik kan word in biomonitering.

Daar is ‘n internasionale neiging om Ekologiese Kwaliteitsobjektiewe (EkoKO’s) in wetgewing in te sluit, veral vir metaalbesoedeling. Binne die raamwerk van EkoKO’s wat vir voëls ontwikkel is, vorm die monitering van besoedelstowwe ‘n spesifieke kategorie van EkoKO’s. Die Verwysings- en Doelvlakke moet egter nog bepaal word as gevolg van ‘n tekort aan data. Die ontwikkeling van EkoKO’s is op hierdie stadium baie belangrik in Suid-Afrika. Die onlangs afgekondigde Nasionale Biodiversiteitswet (10 van 2004) maak spesifiek voorsiening vir die voorbereiding van bewaringsplanne vir geïdentifiseerde ekosisteme wat belangrik is as gevolg van die goedere en dienste wat hulle verskaf. Aangesien daar tans geen bestuursinstrumente bestaan om ‘n toepaslike bestuursplan te ontwikkel nie, is die daarstelling van EkoKO’s wat in lyn is met internasionale standaarde en praktyke van onskatbare waarde vir die implementering van die wet. Vere van museumeksemplare is gebruik om die Verwysingsvlakke vir die verskeie metale in die vere te bepaal. Die Doelvlakke is bereken vanuit die Verwysingsvlakke en is dan vergelyk met die Huidige Vlakke. Die EkoKO’s is dan bepaal vir die metaalvlakke in die vere van wewers in Gauteng, Suid-Afrika.

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LIST OF ABBREVIATIONS

ABPL	Average DNA base pair length
BP2002	Barberspan 2002 survey
BP2005	Barberspan 2005 survey
CAT	Catalase activity
EcoQOs	Ecological Quality Objectives
EQCs	Environmental Quality Criterias
GSH	Reduced glutathione content
HF2002	Holfontein 2002 survey
HGB	Haemoglobin
HMC	Haematocrit
ICES	International Council for the Exploration of the Sea
MCH	Mean Corpuscular Haemoglobin
MCHC	Mean Corpuscular Haemoglobin Concentration
MCV	Mean Corpuscular Volume
OV2002	Olifantsvlei 2002 survey
RK2002	Roodekrans 2002 survey
RK2005	Roodekrans 2005 survey
RV2002	Rietvlei 2002 survey
RV2005	Rietvlei 2005 survey
TEC	Total Erythrocyte Count
TLC	Total Leucocyte Count