ABSTRACT

Rivers always borrow a great part of their character from the terrestrial ecosystems – the catchments – through which they flow. A multitude of natural factors determines the health of a river ecosystem, however, together with these natural factors, the combined influences of urban development, pollution, bank erosion, deforestation (and ironically many forms of afforestation), and poor agricultural practices have so degraded our rivers that they are under severe threat.

One particular group of organisms within river ecosystems that are affected by human-induced changes, are birds. Birds are rather adaptable organisms; many species are able to inhabit human environments very successfully. However, some bird species are highly specialized and adapted to specific environments, like riparian and riverine zones, and their absence or presence is a useful aid in indicating the ecological integrity of an area.

In the past, management of aquatic ecosystems was based primarily on chemical water quality monitoring. However, it is impractical to monitor each component of river make-up in detail, therefore monitoring of biological components (biomonitoring) was also incorporated; using selected ecological indices that are representative of the larger ecosystem, and that are practical to measure.

Common examples of biotic assemblages that have been incorporated into biomonitoring and used in biotic indices are aquatic macroinvertebrates, fish, plants and algae. Each assemblage is useful in its own particular way in providing us with an integrated view of the integrity of the ecological system as a whole. However, little research has been done on the potential of using birds in a suitable index to monitor changes in the environment. Because birds are so easily observed, their species so easily identified, and their distribution so

widespread, it seems viable that birds could also be incorporated into an index of biotic integrity, and used for short- or long-term monitoring of river ecosystems.

The river that was selected for the purposes of this study was the Sabie River, in Mpumalanga, South Africa. The Sabie River catchment falls within the Incomati River basin, which is an international drainage basin occupied by South Africa, Swaziland and Mozambique. Land use in the catchment is characterized by forestry, rural community activities (subsistence and small scale farming of livestock and fruit), and conservation activities, in particular the Kruger National Park. In order to gain better understanding of the functioning and composition of the instream and riparian zones of the Sabie River, certain indices were applied, namely the SASS 5 aquatic invertebrate index, together with the Index of Habitat Integrity (IHI).

For the purpose of being able to compare the biotic integrity of a river system, as indicated by birds, with the condition of instream and riparian components, a Disturbance Index was developed. The Disturbance Index (DI) is an index that is used to measure the extent of human disturbance at any particular site. It incorporates results of various indices, to calculate a score that classifies a site into a specific condition class. The Disturbance Index for the Sabie River was composed of two components; namely, the Riparian Disturbance Index (RDI) and the Instream Disturbance Index (IDI), and by using both of these, an overall DI was determined for each site. These values were also categorised in order to describe each site's general ecological integrity.

Based on the DI, the instream integrity, as measured by the IDI, was excellent at Site 1. This may have been associated with the fact that this site was high up in the catchment, and therefore limited human activities affected the instream component of the system. The riparian integrity of this site (RDI) was however greatly reduced due to the afforestation activities and extensive exotic encroachment. The instream integrity was also good at Site 2 but the riparian

integrity (especially on the right bank) was reduced, due to the presence of a holiday resort. The overall disturbance index (DI) indicated that Site 3 and 4 had the highest level of disturbance, and hence the lowest ecological integrity of all the sites investigated. At Site 3, the primary cause for degradation was agriculture in the form of orchards, while livestock farming contributed mostly to degradation at Site 4. Site 5, 6, 7 and 8 were all situated within the boundaries of the Kruger National Park (KNP), and were thus exposed to fewer human disturbances than Site 1 to 4 were. Site 8 had the lowest level of disturbance, and thus the highest ecological integrity of all the sites sampled.

The bird species diversity over the study period indicated an overall increase from Site 1, situated at the source of the Sabie River, through to Site 8 in the Lowveld, where the river enters Mozambique. This increased bird species diversity could be related to the increase in habitat variability and plant and animal diversity towards the middle and lower reaches of the river, as well as the preservation offered to the rivers within the borders of the Kruger National Park. This in turn provides for a larger diversity of bird species, as more food, foraging and nesting habitats are available.

The data collected over the study period showed clear indications of the preferred habitat of riverine and riparian bird species. Of the species/families observed over the study period, the majority of species had specific habitat requirements. The complete dependence of such specialized species on their particular habitat zones and substrate types makes them especially vulnerable to habitat alteration and degradation. This factor reiterates the necessity to preserve remaining riparian and riverine zones; if conditions in these deteriorate extensively, many of these habitat-specific species will disappear.

In the development of the Bird Index of Biotic Integrity (BIBI), the principles and applications of the conventional Index of Biotic Integrity (IBI) were carefully studied, and the IBI protocol was utilized in this study as a basis for the

development of a multimetric bird index. The final BIBI was compiled, and applied to the data, to assess the biological integrity of the study area. The BIBI proved to be valuable and efficient in highlighting areas of degradation in riparian and instream zones, as well as reflecting the impact that the degradation has on the current bird species diversity.

The overall BIBI scores for the Sabie River increased progressively from Site 1 through to Site 8 indicating an improvement in the ecological integrity. This phenomenon was also evident by the progression in descriptive ecological categories, from poor categories (D and C) at Site 1 to 4, to good categories (B and A), at Site 5 to 8. This increase could have been attributed to the improvement in riparian and instream habitat condition, from the source of the Sabie River, at Site 1, through to Site 8, due to the fact that the river moved from highly impacted areas in the upper and middle catchment (Site 1 to 4), through to minimally impacted areas in the Kruger National Park (Site 5 to 8).

A valuable attribute of the BIBI in comparison with other riverine biotic indices, such as SASS (South African Scoring System) and FAII (Fish Assemblage Integrity Index), is that it has the ability to indicate overall integrity, as well as to distinguish between instream and riparian integrity (similar to the IHI [Index of Habitat Integrity]). In applying the BIBI, many different trophic levels are incorporated as birds are usually at the top of the food chain. Changes in vegetation (producers), invertebrate populations (primary and secondary consumers) and fish (secondary and tertiary consumers), should all be reflected by the animals reliant on them as a source of food. This makes birds, and thus the BIBI, a valuable indicator of overall ecological integrity of river ecosystems.

OPSOMMING

Riviere se eienskappe word grootliks bepaal deur die terrestriële ekostelsels – die opvanggebied waardeur hulle vloei. ‘n Magdom natuurlike faktore bepaal die gesondheid van rivier ekostelsels. Die gesamentlike invloed van stedelike ontwikkeling, besoedeling, erosie, ontbossing (sowel as bosaanplanting), en swak landboukundige gebruike het egter ons riviere uiters gedegradeer en onder groot druk geplaas.

Een besondere groep organismes wat as gevolg van menslike aktiwiteite beïnvloed word, is voëls. Voëls is redelik aanpasbaar en baie spesies kan maklik in menslike omgewings suksesvol oorleef. Sommige voëlspesies is egter hoogs gespesialiseerd en aangepas vir spesifieke omgewings, soos oewer en rivier habitatte. Sulke spesies se teenwoordigheid of afwesigheid kan dien as waardevolle indikators van die ekologiese integriteit van ‘n area.

In die verlede is die bestuur van water hulpbronne hoofsaaklik gebaseer op die monitering van fisies-chemiese waterkwaliteit. Die besef het egter ontstaan dat dit onprakties was om elke waterkwaliteitsveranderlike van ‘n rivier te moniteer asook dat die benadering nie effektief was om die integriteit van ons riviere te bewaar nie. Die monitering van biologiese komponente (biomonitering) is dus ge-inkorporeer deur die toepassing van ekologiese indekse wat prakties is om te meet en wat verteenwoordigend is van die groter ekostelsel.

Voorbeelde van biotiese gemeenskappe wat reeds in biomonitering, en biotiese indekse gebruik word, is akwatiese makro-invertebrate, visse, plante en alge. Elkeen is waardevol op sy eie manier om ‘n ge-ïntegreerde oorsig te gee van die totale integriteit van ‘n ekostelsel. Ongelukkig is daar tot op hede baie min navorsing gedoen en aandag gegee aan die potensiaal om voëls te gebruik in ‘n indeks wat omgewingsverandering kan bepaal. Aangesien voëls so maklik waargeneem word, spesies maklik identifiseerbaar is, en so wydverspreid

voorkom, blyk dit lewensvatbaar dat hulle ge-ïnkorporeer kan word in ‘n indeks van biotiese (biologiese) integriteit, en dus aangewend kan word vir die kort- en langtermyn monitering van rivier ekostelsels.

Die Sabierivier (Mpumalanga) is gekies vir die doel van die studie. Die opvangsgebied van die rivier val binne die Inkomati stelsel, wat ‘n internasionale opvangebied beset binne Suid-Afrika, Mosambiek en Swaziland. Landgebruike in die opvangsgebied sluit onder andere bosbou, informele nedersettings en hul ge-assosieerde aktiwiteite (onderhouds- en klein skaal aanhouding van vee en verbouing van groente en vrugte) en bewaringsaktiwiteite (in besonder die Nasionale Krugerwildtuin) in. Bestaande indekse, naamlik die SASS5 akwatiese invertebraat indeks, asook die Habitat Integriteits Indeks (IHI) is toegepas om die huidige samestalling en integriteit van die Sabierivier se binnestroom- en oewer sones te bepaal.

‘n Versteuringsindeks is ontwikkel vir die doel om die biotiese integriteit van die Sabierivier, soos aangedui deur voëls, te vergelyk met die kondisie van die oewer- en binnestroom komponente van die rivier. Die indeks was gebruik as ‘n maatstaf van die hoeveelheid menslike versteurings wat by ‘n lokaliteit voorkom. Dit inkorporeer die resultate van verskeie bestaande indekse om ‘n lokaliteit in ‘n spesifieke kondisieklas te klasifiseer. Die algehele versteuringsindeks vir die Sabierivier het uit twee onderlinge afdelings bestaan, naamlik die oewer versteuringsindeks en die binnestroom versteuringsindeks.

Op grond van die versteuringsindeks is die binnestroom integriteit van lokaliteit 1 as uitstekend geklassifiseer. Dit is as gevolg van die posisie van die lokaliteit hoog in die opvangsgebied wat dus beperkte menslike aktiwiteite stroomop bevat wat die binnestroom komponent van die rivier nadelig kan beinvloed. Die integriteit van die oewer komponent van die lokaliteit, soos bepaal deur die oewer versteuringsindeks, was egter grootliks verlaag as gevolg van bosbou aktiwiteite en die teenwoordigheid van indringer, uitheemse plantegroei in die

oewergebied. Die binnestroom integriteit was ook goed by lokaliteit 2, maar die oewer kondisie (veral regter bank) was grootliks verlaag as gevolg van ‘n vakansieoord. Die algehele versteuringsindeks het daarop gedui dat lokaliteite 3 en 4 die hoogste graad van versteuring, en dus die laagste integriteit, van alle lokaliteite gehad het. By lokaliteit 3 was landbou in die vorm van vrugteboorde die primêre oorsaak van degradering, terwyl vee boerdery grootliks vir lokaliteit 4 se degradering verantwoordelik was. Lokaliteite 5, 6, 7 en 8 was almal geleë binne die grense van die Nasionale Krugerwildtuin, en was dus blootgestel aan ‘n laer graad van versteuring as lokalitiete 1 tot 4. Lokaliteit 8 het die laagste graad van versteuring, en dus die hoogste ekologiese integriteit, van al die lokaliteite gehad.

Die voëlspesiediversiteit oor die studie periode het gedui op ‘n algehele verhoging vanaf lokaliteit 1, naby die oorsprong van die rivier, tot by lokaliteit 8, in die Laeveld. Die toenemende voëlspesiediversiteit stroomaf kan wees as gevolg van die toename in habitatdiversiteit en dus geassosieerde plant en dier diversiteit in die middel en lae streke van die rivier, sowel as die bewaring van die habitat integriteit binne die grense van die Nasionale Krugerwildtuin (lokaliteite 5 tot 8). Dit bied op sy beurt weer ‘n groter diversiteit van voëls, as gevolg van meer voedsel, voedings- and nesmaak habitatte wat beskikbaar is.

Die data wat oor die studie tydperk ingesamel is het ook duidelike aanduidings gegee van habitatsvoorkeure van sekere binnestroom- en oewervoël spesies. Die algehele afhanklikheid van sulke gespesialiseerde spesies op hul spesifieke habitatte en substraat tipes maak hulle veral kwesbaar vir habitats veranderinge en degradering. Dit beklemtoon die noodsaaklikheid om die oorblywende binnestroom en oewer sones te bewaar, aangesien die verlies en degradering van die habitatte mag lei tot die verdwyning van die habitat-spesifieke spesies.

Die beginsels en toepassing van die konvensionele Indeks van Biotiese Integriteit (IBI) is bestudeer en die protokol is gebruik tydens die huidige studie

as die basis vir die ontwikkeling van ‘n Voël Indeks van Biotiese Integriteit (BIBI). Die data versamel tydens die studie was toegepas in die BIBI om die biotiese integriteit van die Sabierivier, op grond van sy voëlgemeenskappe, te bepaal. Die BIBI was waardevol en effektief om degradering in die oewer en/of binnestroom gebiede uit te wys, asook om die totale impak op die voëlgemeenskappe te reflekteer.

Die BIBI waardes bepaal vir die lokaliteite in die Sabierivier het getoon op ‘n stelselmatige stroomaf verbetering in ekologiese integriteit. Dit was ook aangedui deur die progressie in beskrywende klasse, wat gestrek het vanaf swak (D en C) by lokaliteit 1 tot 4, tot goed (B en A) by lokaliteite 5 tot 8. Hierdie stroomaf verbetering in BIBI waardes en klasse kan toegeskryf word aan die stroomaf verbetering in oewer en binnestroom habitat kondisies soos die rivier beweeg het vanaf hoogs ge-impakteerde areas in die bo- en middelopvangebiede (lokaliteiet 1 tot 4), na ‘n minimaal ge-impakteerde area in die Nasionale Krugerwildtuin (lokaliteite 5 tot 8).

‘n Baie waardevolle eienskap van die BIBI, in vergelyking met ander rivier biotiese indekse soos SASS en FAII, is sy vermoeë om die algehele biotiese integriteit van ‘n area te bepaal, sowel as om onderskeid te tref tussen die binnestroom area en die oewer area. In die toepassing van die BIBI word verskillende trofiese vlakke ook ge-inkorporeer aangesien voëls bo aan die voedselketting is. Verandering in die plantegroei (produsente), invertebraat bevolkings (primêre en sekondêre verbruikers) en vis (sekondêre en tersiêre verbruikers) behoort dus gereflekteer te word deur die diere wat afhanklik is van hulle as voedsel (voëls). Dit maak voëls, en dus die BIBI, ‘n waardevolle indikator van die algehele ekologiese integriteit van rivier ekostelsels.