STATUS AND TRENDS OF JUKSKEI RIVER SYSTEM, SOUTH AFRICA. NATIONAL TOXICITY MONITORING PROGRAMME (NTMP)

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Introduction

Chapter 14 of the National Water Act (Act No. 36 of 1998) specifically requires the Minister of the Department of Water and Environmental Affairs to establish a national monitoring systems that can assess, among other matters, the quality of water resources and the health of aquatic ecosystems. The National Toxicity Monitoring Programme (NTMP) described herein focuses on the water quality component of inland water resource quality. A needs assessment for the NTMP was performed in 2002 prior to embarking on the design phase (DWA, 2003). The objectives, target users, criteria for choosing toxicants, an approach for choosing toxicity tests, and various other general design considerations were identified.

Furthermore, the NTMP was developed in response to increasing local and international concerns about the detrimental effects of toxicants that are being released into the environment. The aim of the project is to report on the status of and trends in the occurrence of toxicants and toxicity at a national level and also to help fill the information gap between the National Chemical Monitoring Programme (NCMP) and the River Health Monitoring Programme (RHMP).

This programme uses a combination of chemical and bio-assessment methods i.e. by monitoring toxicity variables at different trophic levels, namely fish, invertebrates (*Daphnia*) and plants (algae).

This is a relatively new monitoring programme to address the issues surrounding new emergency contaminates such as Endocrine Destructing Compounds (EDCs), which were not originally accommodated in the 1996 South African water quality guidelines. The report presents the chemical analysis of selected organic compounds and toxicity effects data, for water samples collected at three sites along the Jukskei River (i.e. Marlboro, Midrand and N14).

Materials and methods

Sampling Sites

The Jukskei River is one of the largest Rivers in Johannesburg with the catchment covering an area of 800 km^2 including many of the highly industrialised and urbanised parts of Johannesburg. This River which is one of the main tributaries of the Crocodile River flows northward through to Hartebeespoort dam. It is characterised by high level of pollution mainly from contaminated storm water run-off, effluent discharges from industries and wastewater treatment works, sewage systems, leachates from old landfill sites and overcrowding along the river bank in Alexandra area (Campbell 1996). The sampling site with GPS coordinates for selected sites (Table1) and the map of Gauteng showing the position of Jukskei Catchment (Figure1) are shown below. These three sites were also used during the Piloting Phase of the NTMP. All the sites chosen were expected to be reasonably contaminated with toxicants.

The Marlboro site is downstream of a major industrial complex and Alexandra township. About 5km downstream of this site is the Midrand site. The N14 site is situated under a bridge a 1000m downstream of the Johannesburg Northern waste water treatment Works discharge.

Sampling procedure

Between October, 2011 and Novermber, 2012 samples were collected on a weekly basis. Using a 4l brown Winchester bottle for the chemical analysis and a 5L glass bottle for toxicity tests. After collection, samples were transported to the laboratory in cooler boxes and were kept at -4^{o}C until extraction and analysis. A total of 48 water samples were collected for summer and winter. These samples were analysed for both selected organic chemicals and toxicity effects on different organism as listed in Table 2 and 3.

Laboratory analysis

Organic chemical analysis for selected compounds were performed using gas chromatography according to the (DWA, 2007) method. Surface water ecotoxicity was evaluated using a battery of bioassays according to the NTMP standard methodology (DWA, 2006).

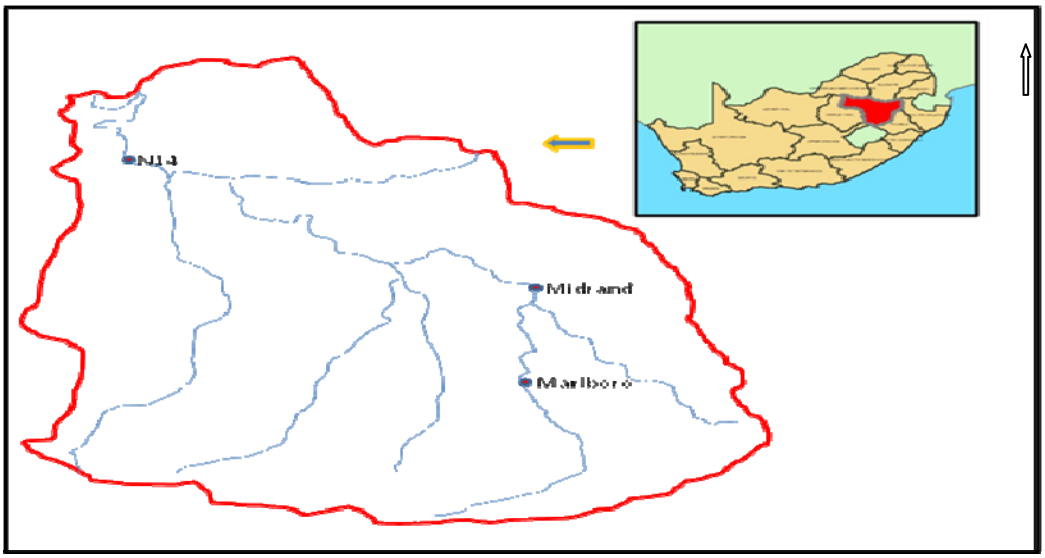

Figure1: Map of study area Jukskei River system on A21C Quaternary Catchment (center) map of South Africa (Top right) showing 19 Water Management Areas (WMA).

Table 1: GPS coordinates of the sites and their WMS numbers

Sample Point	WMS Feature ID	GPS coordinates	
Marlboro	188571	S 26^{O}05'05.7"	E 28^{O}06'31.7"
Midrand	90186	S 26^{O}01'53"	E 28^{O}06'43.9"
N14	188572	S 25^{O}56'57.6"	E 27^{O}57'31.6"

Results and discussion

The compounds currently monitored as indicated below in Table 2 include the group of POPs that have historically been used in the country. Organochlorine pesticides such as Aldrin and Dieldrin, DDT and its metabolites which are still used on a limited basis for malaria mosquito vector control. Phthalates from plastics, Triazine herbicides (Atrazine), Organ-phosphorus pesticides (Dichlorvos), also included are some Polycyclic aromatics compounds such as Naphthalene and Polychlorinated Biphenyls compounds. Most of the organic chemicals investigated were detected at all the selected sites as shown in Table 2 below.

Organic chemical analysis

Polycyclic aromatic hydrocarbons (PAH): There are no guideline values for most of the polycyclic aromatic hydrocarbons with the exception of Naphthalene (16µg/l). The Marlboro site had the highest mean concentrations for this group of compounds while the mean concentrations for Acenaphtene, Acenaphthylene and Benzo (a) pyrene were found to be below the quantification limit (0.03µg/l) at some of the sites hence, cannot be adequately quantified. Polychlorinated biphenyls (PCBs): Also has no guideline values, the mean concentration of the sum of Arochlor 1254 (i.e. Arochlor i, ii and iii) were found to be higher when compared to last year results (0.073µg/l). Dibenzofuran was detected from all the sites and the highest mean concentration was recorded at the Marlboro site. Organochlorine pesticides: Lindane mean concentrations detected were all below the guideline value of (0.2 µg/l) at all the sites. No guideline values exist for the other Organochlorine pesticides tested. The highest mean concentrations of all Organochlorine pesticides were however recorded at

the Midrand site (1.078µg/l) for BHC-beta. Also DDT was detected at all the sites but just below the quantification value.

Table 2:Mean levels (µg/L) and SD of selected organic variables in Jukskei river for 2012 hydrological cycle.

Compound µg/l	DL µg/l	Marlboro	Midrand	N14	WQGVµg/l
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	0.001	0.01±0.01	0.003±0.004	0.006±0.007	NWQGV[i]
Acenaphthylene	0.001	0.002±0.004	0.001±0.003	0.001±0.0	NWQGV
Benzo(a)pyrene	0.001	0.008±0.01	0.001±0.0	0.001±0.0	NWQGV
Fluoranthene	0.001	0.046±0.036	0.041±0.035	0.04±0.04	NWQGV
Naphthalene	0.001	0.025±0.139	0.01±0.048	0.007±0.031	16
Phenanthrene	0.001	**0.058**±0.038	0.040±0.029	0.040±0.035	NWQGV
Polychlorinated Biphenyls					
Arochlor 1254	0.001	**4.896±0.722**	**4.896±0.722**	**4.889±0.745**	NWQGV
Dibenzofuran	0.001	0.067±0.132	0.036±0.078	0.041±0.089	NWQGV
Organochlorine Pesticides					
BHC-alpha	0.001	0.006±0.01	0.262±0.201	0.038±0.35	NWQGV
BHC-beta	0.002	0.009±0.026	**1.078**±0.921	0.185±0.145	NWQGV
BHC-delta	0.001	0.056±0.347	0.023±0.026	0.011±0.019	NWQGV
BHC-gamma (Lindane)	0.001	0.003±0.009	0.005±0.005	0.003±0.005	0.2
DDT 4,4'	0.001	0.001±0.0	0.001±0.0	0.001±0.0	0.01
Organophosphorus Pesticides					
Dichlorvos	0.001	0.028±0.189	0.001±0.0	0.001±0.0	NWQGV
Dimethoate	0.001	0.067±0.355	0.001±0.0	0.001±0.0	0.15
Phthalates					
Butyl benzyl phthalate	0.001	0.026±0.022	0.019±0.018	0.021±0.02	NWQGV
Di-n-butyl phthalate	0.002	**3.383±9.105**	2.591±5.601	2.445±5.242	26
Diethyl phthalate	0.001	1.047±1.217	0.366±0.237	0.636±0.538	1000
Di-n-hexyl phthalate	0.001	0.021±0.016	0.017±0.011	0.019±0.0	NWQGV
Dimethyl phthalate	0.002	0.145±0.472	0.126±0.433	0.236±0.499	3700
Di-n-octyl phthalate	0.001	0.008±0.01	0.005±0.008	0.004±0.005	NWQGV
Triazine Herbicides					
Atrazine	0.001	0.294±0.153	0.337±0.193	**0.408**±0.203	10

N= Number of samples, DL= Detection limit, M=Mean, SD= Standard Deviation, NWQGV= No water quality guideline and Value= South African Water Quality Guidelines (DWAF 1996).

Organophosphorus pesticides : these class of compounds were detected at all the sites. There is no South African guideline value for most of these compounds except dimethoate (0.15µg/l) and the highest mean concentration detected at the Marlboro site was (0.067µg/l). Phthalates : all the Phthalates monitored were detected from all the sites. The mean concentrations of dibutyl phthalate, diethyl phthalate, and dimethyl phthalate were all below the guideline values of (26µg/l, 1000µg/l, and 3700µg/l) respectively. Although the highest concentration obtained for the phthalates was Di-n-butyl phthalate with a value of 3.383µg/l at the Marlboro site, lower than last year value of (10.44 µg/l) from the same site. Polychlorinated biphenyls (PCBs): also, no guideline values for any of the PCBs congners. The mean concentration of the sum of Arochlor 1254 (i.e. Arochlor i, ii and iii) were found to be higher when compared to last year result (0.073µg/l). Dibenzofuran was detected from all the sites and the highest mean concentration was recorded at the Marlboro site again.

Toxicity analysis

There were significant acute toxicity response observed for fish (*Danio rerio*) at all the sites, with Marlboro being the most toxic water sample (Table 3). For zooplankton (*Daphnia pulex*) no significant acute toxicity response was observed for Midrand. Also, chronic test like algal (*Selenastrum capricornutum*) growth stimulation and bacterial rapid test (*Vibrio fischeri*) luminescence stimulation test showed a positive response in water samples from all the sites. Zooplankton reproduction stimulation was positive at all the sites, showing that the water medium was enriched with nutrients during this period. However, algal (*Selenastrum capricornutum*)

and bacterial (*Vibrio fischeri*) growth inhibition was only observed at the N14 site for 19% and 40% of test samples respectively.

Table 3: Annual mean response and percentage samples showing toxicity effect for Jukskei river in 2012

	Marlboro		Midrand		N14	
Toxicity test	% Mean response	% samples With effect	% Mean response	% samples With effect	% Mean response	% samples With effect
D R % E&LM	60.3	97.92	26.1	95.83	22.6	100
DP % Mortality	26.0	100	<dl (17.0)	97.92	20.3	100
D P % RS_{21Dayd}	137.0	68.75	139.3	70.83	109.7	70.83
D P % RM_{21Days}	47.0	85.42	27.6	85.42	22.1	87.5
SC,% GS_{96Hr}	108.0	87.5	84.3	85.42	73.1	70.83
SC % GI_{96Hr}	N/A	0	N/A	0	78.3	18.75
V F % GI_{Rapid}	<dl(10.0)	2.08	26.0	2.08	35.7	39.58
VF % GS_{Rapid}	41.7	97.92	45.1	95.83	30.0	30

DR = Danio rerio, E&LM = Embryos and Larvae Mortality, DP = Daphnia pulex, RS_{21DAYS} = 21 days Reproduction Stimulation, RM_{21DAYS} = 21 days Reproduction Mortality, SC = Selenastrum capricornutum, GS_{96H} = 96 hrs Growth Stimulation, GI_{96H} = 96hrs Growth inhibition, VF = Vibrio fischeri, GI_{Rapid} = Rapid Growth inhibition and GS_{Rapid} = Rapid Growth Stimulation

In conclusion, the concentrations of selected organic chemicals indicated that the water quality was worse-off at the Marlboro site when compared with the other two sites along the Jukskei River system. Also, the toxicity test corroborate with the results from the organic variables, showing that more of the organisms with positive response were found in the Marlboro samples. Hence, this may be due principally to the activities surrounding the site i.e. downstream of a major industrial complex and the proximity to the densely populated Alexandra township.

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