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Research article

Towards tradable permits for filamentous green algae pollution

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ABSTRACT

Water pollution permit systems are challenging to design and implement. Operational systems that has maintained functionality remains few and far between, particularly in developing countries. We present current progress towards developing such a system for nutrient enrichment based water pollution, mainly from commercial agriculture. We applied a production function approach to first estimate the monetary value of the impact of the pollution, which is then used as reference point for establishing a reserve price for pollution permits. The subsequent market making process is explained according to five steps including permit design, terms, conditions and transactional protocol, the monitoring system, piloting and implementation. The monetary value of the impact of pollution was estimated at R1887 per hectare per year, which not only provide a “management budget” for filamentous green algae mitigation strategies in the study area, but also enabled the calculation of a reserve price for filamentous green algae pollution permits, which was estimated between R2.25 and R111 per gram filamentous algae and R8.99 per gram at the preferred state.

1. Introduction

In a free market economy, private (firm and individual) production and consumption decisions are based on trade-offs between willingness to pay and accept of private costs and benefits, which are reflected in market prices. According to neoclassical economics, the ‘invisible hand’ of the market is assumed to ensure that these private decisions will lead to socially optimal outcomes, such as optimal levels of production and pollution (Goodstein, 2008). However, people tend to give more prominence to private costs and benefits, resulting in choices that are not always socially optimal, and when the costs of producing a product or the benefits from consuming a product spill over to people who are not involved in the consumption or production of the good, an externality occurs. Such external impacts are thus unaccounted for costs (such as pollution) and benefits (such as education) of which the effect the market fails to accommodate in the market price, i.e. the market “fails”. Consequently, market prices often fail to adequately reflect the full *social* costs and benefits associated with these goods or services, owing to the existence of externalities. Subsequently, the levels of production and pollution will not be socially optimal because the trade-offs are not accurately reflected. With negative externalities specifically, social costs exceed private costs, such that too much of the activity will be undertaken relative to the socially optimal amount. Pollution is an example of a negative externality (an external cost of production or consumption) where market prices provides incentives for too much environmentally damaging behaviour. ‘Internalising’ such externalities therefore become necessary to re-adjust prices in such a way that the negative impacts of pollution will be taken into account by the polluters. However, such re-adjustment requires an estimate of the monetary value of the impacts of pollution. Such valuations not only enables this internalisation process, but can also be used to compare different pollution mitigation strategies within a particular area and to a lesser extent, similar areas. Such valuations can also enable the use of more advance policy instruments such as tradable pollution permits. These permits is a form of market-based governance which seeks to change behaviour by changing price signals to which rational and economically driven actors are expected to respond in their own self-interest. In this way, markets may harness the decentralised power of individual decision-makers to achieve policy objectives set by government who also design the terms, conditions and transactional protocol for the market and regulate its subsequent operation.

South African policymakers have a much bigger variety of environmental protection tools at their disposal than they did 20

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years ago; when so-called command and control mechanisms to regulate unwanted behaviour was the preferred approach. Although this approach was effective in some areas, it proved to be costly and difficult to enforce for water pollution because of the high level of monitoring required by methods based on this approach. However, market-based mechanisms have put forward potential alternatives to command and control mechanisms. These mechanisms could take the form of subsidised reforms, taxes to account for social costs, or the establishment of markets in which pollution permits (i.e. the right to pollute a certain amount per time period) can be traded. The latter is of particular interest for this study as it not only aims to limit pollution at an optimal cost to the polluter, it also create an incentive for companies to reduce pollution further (relative to their entitlement), since it becomes possible to sell the difference to willing buyers (i.e. a firm who cannot meet their pollution targets) for a profit. Although such trading happens within a predetermined pollution standard it can lower the cost of compliance while realising pollution prevention benefits. Market-based systems thus capitalize on the power of the marketplace to reduce pollution cost-effectively and use economic incentives to promote conservation (David, 2003). It does however require an innovative market making process to design the necessary terms and conditions that will allow fair trade. None the less, recent general and empirical evidence of success does exist in the literature (Kraemer et al., 1999; Goulder, 2013; Newburn and Woodward, 2012; Ribaudo and Gottlieb, 2011; Shortle, 2013; Van Houtven et al., 2012; Wiedeman, 2001) – all within the developing world. We build on this body of literature by presenting progress been made within a developing country context. We present the results of a monetary estimate of the impact of nutrient enrichment (filamentous green algae) impacts on commercial agriculture in the Dwars River, Western Cape (De Lange, 2014) in South Africa where the filamentous algae often deplete sections of rivers from oxygen leading to eutrophic conditions, fish kills and an increase the operation and maintenance cost of irrigated agriculture.

This is done by presenting the study area, discussing the methodological approach, presents the surveyed pollution impacts and the calculated monetary value of the impacts of such pollution. The market making process is then discussed along with a first attempt at the initial price setting and description of terms, conditions and transactional protocol for such a system in South Africa. The paper concludes with a short interpretation of the results and discusses the potential applications of the results.

2. Approach for valuation pollution impacts

We applied a production function approach (Birol et al., 2006; Brouwer and Pearce, 2005; Glazyrin et al., 2006; Pearce, 1993, 1994), to estimate the monetary value of the impact of filamentous algae on commercial agriculture. The main emphasis was on the impacts of filamentous algae growth on farm profitability which relied on detailed information on the impact(s) and the extent of the impact(s) of filamentous algae on farming practice. The input data for the calculations were obtained from interviews with prominent farmers in the study areas and the operations and general managers of both water user associations. The basic valuation procedure followed these steps:

1. Representative crop selection and construction of a typical farm profile for each representative crop.
2. Description and quantification of the impacts of filamentous algae on the cultivation practice of representative crops.
3. Valuation of the impact of filamentous algae.
4. Aggregation and extrapolation to the level of the water user association.

Representative crops were selected in terms of hectares under irrigation in each study area. We have interviewed some of the prominent farmers of the representative crops and asked them to explain the impacts of filamentous algae on their business focusing specifically on the impacts of filamentous algae on the cultivation practice. It is assumed that filamentous algae are always present in the water and that a difference in concentration levels is considered the distinguishing factor determining the mitigation strategy and hence cost implications and consequent profitability impacts. Therefore, farmers were asked to try and distinguish between a “heavy” and a “normal” filamentous algae load scenario.

The cost implications of the impacts of filamentous green algae was determined by systematically accounting for the cost variables involved in mitigating (i.e. managing) the impacts of filamentous algae. This process was done in close collaboration with farmers because mitigation strategies for filamentous algae differ between farms. Steps in their filamentous algae mitigation process while noting the cost implications. The cost was systematically captured in a spreadsheet in order to calculate the total direct cost of the on-farm pollution mitigation process.

We structured the cost impacts according to the crop enterprise budget (cost structure for standard cultivation practice) for each representative crop. Industry data was obtained from HORTGRO, SAWIS, VINPRO, NULANDIS and KAAPAGRI.

3. Study area and representative crops

The Dwars River is a major tributary of the Berg River which is the major source of water supply to the Cape Town metropolitan area. It is an area with high rainfall on the peaks (>3000 mm/yr) but with very steep rainfall gradients. Although the area is about 10% of the surface area of the relevant quaternary catchment, it yields 24% (approximately 23 million m^3/yr) of mean annual runoff of quaternary catchment. The average rainfall is 877 mm/yr.

Commercial agriculture in the Dwars River focuses (in terms of hectares) on deciduous fruit and viticulture (DFPT, 2013). Plums were taken as representative deciduous fruit crop since it represents 70% (307 ha) of the area under deciduous fruit, there is also approximately 355 ha of irrigated wine grapes in the study area (SAWIS, 2013) (Fig. 1).

4. Surveyed pollution impacts

Filamentous green algae thrive under eutrophic conditions due to nutrient enrichment from raw or partially treated sewage, agricultural effluent and other forms of phosphorous rich pollutants (Oberholster and Botha, 2011; 2013). Although filamentous algae pose no direct threat to crops, it affects the operational efficiency of irrigation systems and therefore affects the operation and maintenance costs of irrigation infrastructure, which increases downstream. It should be noted that although pollution loads could vary during the year, the impacts affect farmers during the irrigation season which starts in the third week of October until the second week of March for the Dwars River.

There is no bulk supply infrastructure in the Dwars River (farmers draw water directly from the river). Most farmers were aware of the direct relationship between bio-available phosphate and filamentous algae and were of the opinion that filamentous algae affects farm profitability directly via increased irrigation costs. Filamentous algae not only obstructs and clogs strainers, intake valves and manifolds, but also places a higher load on impellers and bearings of pressure pumps, while decreasing the