



REVIEW ARTICLE

Effect of purified wastewater from the city of Settat (Morocco) on the quality of *Lippia citriodora* essential oil and infusion



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Wastewater;
Limonene;
Neral and geranial

Abstract *Lippia citriodora* is an aromatic plant largely consumed in Morocco and throughout the world. It is well-known for its use in the field of food, medicine and aroma therapy. The production of this plant is for its local uses and for export. The therapeutic activity of *L. citriodora* or its extracts mainly depends on the quality of finished products.

In this study, we aimed to evaluate the effect of irrigation with urban wastewater from Settat (Morocco) treated by lagoons on the composition of the essential oil, essential oil yield and physico-chemical composition infusion of *L. citriodora*.

The soil used for the implantation is characterized. Physico-chemical analyses of well water and wastewater used for irrigation are analyzed.

From the results obtained we found changes in the composition of the essential oil of a large number of constituents. After irrigation of *L. citriodora* by wastewater we observe changes in major compounds in the essential oil: decreased neral (from 15.29% to 14.34%) and geranial (from 15.63% to 14.75%) and increased limonene (from 23.39% to 25.86%). We deduce that wastewater has a beneficial effect in increasing the yield of essential oil.

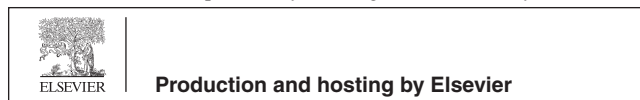
The infusion of *L. citriodora* prepared by the fresh and dried leaves irrigated with wastewater contains a high concentration of NH_4^+ , Ca^{2+} , Mg^{2+} , and the concentration of $\text{NO}_2\text{-N}$ (mg/L) exceeds 100% of the concentration of waste water.

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1. Introduction

Volume of water used in the world has grown more than twice the rate of population growth, and a growing number of regions reached the limit beyond which it is no longer possible to provide reliable water (for different uses) (FAO (2007). Agricultural reuse of wastewater is a process increasingly integrated into the policy management of water resources, even in industrialized countries and emerging economies, as evidenced by studies in Spain (Cazurra, 2008), Italy (Lopez and Vurro, 2008) and China (Wang et al., 2007). The genus *Lippia* (Verbenaceae) includes approximately 200 species of herbs, shrubs and small trees (Terblanché and Kornelius, 1996).

The lemon verbena, *Aloysia triphylla* (L'Herit.), Britt's = *Lippia citriodora* (Lam.), grows spontaneously in South America and is cultivated in North Africa (Morocco) and Southern Europe. In these areas, the leaves are largely used as herbal tea for their aromatic, digestive and antispasmodic properties. The lemon verbena is a folk remedy for colds, fever, spasms asthma, flatulence, colic, diarrhea, indigestion, insomnia and anxiety (Duke, 1985; Bézanger-Beauquesne et al., 1990; Carnat et al., 1999). The essential oil from its leaves has been shown to exhibit antimicrobial activity (Duarte et al., 2005; Duschatzky et al., 2004; López et al., 2004; Ohno et al., 2003; Sartoratto et al., 2004). A number of publications deal with the analysis and identification of the phenolic compounds (flavonoids and phenolicacids) of the leaves of *L. citriodora* (Carnat et al., 1995, 1999; Nakamura et al., 1997; Skaltsa and Shamas, 1988; Tomas-Barberán et al., 1987; Valentão et al., 1999). The chemical composition of the essential oil from the leaves of *L. citriodora* has also been studied and reviewed (Bellakhdar et al., 1994; Carnat et al., 1999; Catalan and de Lampasona, 2002; Crabas et al., 2003; Kim and Lee, 2004; Montes et al., 1973; Özek et al., 1996; Pascual et al., 2001; Santos-Gomes et al., 2005; Sartoratto et al., 2004; Terblanché and Kornelius, 1996; Velasco-Negueruela et al., 1993; Von Kaiser and Lamparsky, 1976a,b; Zygadlo et al., 1994). The genus

Lippia shows a rich genetic diversity, enabling it to synthesize a variety of essential oil constituents in plants grown in different parts of the world (Catalan and de Lampasona, 2002; Santos-Gomes et al., 2005). However, the composition of the essential oil obtained from the same plant stock remains constant under the same environmental conditions (Catalan and de Lampasona, 2002; Santos-Gomes et al., 2005).

Perennial aromatic plants are cultivated as cash-crops for fresh or dry herb production, or as a source of essential oils and natural antioxidants. These summer crops require substantial amounts of water, up to 7000–9000 m³ ha⁻¹ throughout the growing season, to satisfy their potential for intensive biomass production (Putievsky et al., 1990; Dudai, 2005).

Hundreds of hectares of these crops are required to facilitate an economically viable industrial production system. Therefore, shortage of fresh water for irrigation in arid and semiarid regions restricts utilization of aromatic plants as industrial crops. Replacement of fresh water with treated effluent for irrigation of these plants could promote the development of large-scale production systems for biomass, essential oil, and natural antioxidants in arid and semiarid zones. Cultivation of aromatic plants for essential oils is suitable for irrigation with treated effluents because the heat applied during oil extraction eliminates human bacterial pathogens originating in the effluents and alleviates health concerns. Additionally, the essential oil, which is extracted mainly by steam distillation, will be free of inorganic ion contaminants such as heavy metals originating from the effluents, which may accumulate in the plant tissues and the soil (Nirit Bernstein et al., 2009).

2. Materials and methods

2.1. Framework and population of Settat city

Settat City, located on the road Casablanca–Marrakech 72 km south of Casablanca, is the urban core of the province. This latter, with 9888.4 km², is characterized by its agricultural

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