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Catalysis of stranded material on beaches in Arauco, Chile: experience with stranded sardines as fertilizer with a chemical solution

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Abstract

Fish stranding or beaching is an infrequent but recurring phenomenon on the Chilean coastline and generates a serious public emergency. This phenomenon has been significantly reported around the mouth of the Laraquete River in Arauco, generally associated with water temperature changes and creating major environmental and public health problems due to the amount of organic matter deposited and outgassing from decomposition. This material is removed and taken to specialized landfills at a high cost, which merely transfers the problem without fundamentally solving it. Recently a product has been developed which appears capable of catalyzing organic material without the need for bacterial fermentation and increasing the bioavailability of soil nutrient materials. We evaluate this by using the product at the recommended concentration and doing on-site measurements of nitrites, nitrate, nitrogen, and phosphate levels. These showed, that after a 12-hour incubation period, the compounds increase, and organic material releases these compounds into a nutritious mud or organic compost. The smell was also evaluated as an indication of decomposition processes, with no changes recorded. The catalyzed material was transported to a farm site, mixed with low-quality soil, and subsequently planted with oats, reporting an output of over 90% in the soil treated with the catalyzed material. Health authority reviews raised no reports about odors. This data indicates that the product can release nutrients into the mud, generating organic compost, which can used for fertilizer in agricultural work. Future reports can indicate how this allows for new organic waste management strategies.

Keywords: Catalysis, Fertilizers, Mortality, Pollution

1 Introduction

Fish stranding or beaching is a problem on shorelines since they create massive biomaterial deposits that decompose in a small area. The main problem is that their decomposition swiftly generates increased harmful gasses, which impact public health [1, 2]. This problem is managed in Chile via removing the material and disposing of it in special landfills as contaminated material, which is a costly and inefficient process, as it only transfers the problem between different locations (Instructive SERNAPESCA Chile). Some alternatives, have been offered, including using traditional odor neutralizers [3], chelators, feeding bioreactors with the material or placing a bacterial inoculation to increase its decomposition [4]. However, discussions indicated that these steps are hard to implement due to cost and volume issues, so new forms must still be considered to work with this type of material, i.e., high-volume waste presents major public health issues [5, 6]. Decomposition is a process where microbiota (bacteria, fungi, protozoa and others) and saprobiotic organisms begin the process, releasing molecules which feed the successive food chain links [7]. Carbon from organic compounds which is not used in cellular protein is freely released in the reduced form of methane (CH4), while much of the carbon is an energy source for organisms and is consumed as carbon dioxide ($C0_2$) [8].

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This decomposing biomass reaches its own internal temperature, and ambient temperature regulates the speed of the process [8, 9]. Following outgassing, the active decay stage begins, where other volatile fatty acids are produced based on the ongoing decomposition of muscles, proteins, and fats, producing phenolic compounds and glycerol. Decomposition products, including putrescine and cadaverine, are also detectable in this stage, adding to insect activity [10]. We must consider the acute release of these compounds, volatile amines, gasses, and acids as a source of pollution which also generates ecotoxicological problems and must receive bioremediation [11, 12]. In general, temperature, pH and microbial load conditions allow for decomposition reaction catalysis at swifter-than-normal speeds, but which still take months [13, 14]. This is the principle of composting, which can accelerate a biochemical process via closed conditions. Accelerating a reaction [15] in chemistry is defined as the capacity to reduce the energy needed to transform a substrate into a product. This phenomenon is generated by molecules with enzymatic ability, permitting the generation of a typical reaction curve with constants defined in the Michaelis-Menten equation [14]. A molecule with this reaction style can be considered an enzymatic catalyst which reduces reaction energy and time [14]. Within these parameters, it has been indicated that material generated in organic systems can be unloaded as organic compost. This has specific characteristics ranging from its organic matter content, humidity and physicochemical properties to the way this system can be used in agricultural work as a fertilizer and an alternative to compost which takes less time, although it has lower nutritional value according to its origins [16, 17]. The development of the TCAS CATA™ compound by the TEQUIA company was evaluated on-site in order to control this kind of environmental emergency and prevent public health problems. An initial report was generated about how it can catalyze organic material and create organic compost suitable for farming, presenting the result of a novel way to manage fish stranding or beaching without production of organic wastes and generating an organic compound for direct soil application. This novel process is a complete organic waste management pathway for the future.

2 Methods

2.1 TCAS-CATA

TCAS-CATA, a product under the patent register and product register in national law, is a complex mixture of chemical compounds and one anionic surfactant Sodium Dodecylbenzene Sulfonate SDBS as an active principle, reported to the national environment service in Chile, the product is used in different concentrations between 0.5 at 5% depended on the action. In this we used 1% of the product in V/V dilution. The organic material is mixed direct with TCAS CATA solution, leave for 12 h for catalyst and then the mixture are deliver direct to soil for integration and used for agricultural work.

2.2 Obtaining samples

We used sardine samples from accidental fish strandings gathered from the river by fishers in the local emergency, which were stored in 200-l drums with the TCAS CATA™ solution at a 2 to 1 sardine-catalyst ratio., at 1% of V/V concentration. A total of 3 ton of sardines are controller with product. Samples for biochemistry and odor observation were prepared by taking samples, in 6 continuous days for 3 different batch of the reaction catalyzed for 12 hours in the drums into a sample flask with a 20 ml volume and carrying out parameter measurements. Samples of soil with and without catalyst were taken in 20 ml flasks and kept dry. Ten milliliter of water were added per 20 g of earth, and the supernatant was taken for biochemical measurements.

2.3 Odor evaluation

Independent observers, 4 different for every independent experiment, were asked to indicate disgust on a subjective scale of 0 to 4 in three cases: before treatment, after treatment application and in samples from the same time without treatment. This was done following the considerations of the NCh3190 norm regarding static or land observations of environmental odor evaluation.

2.4 Nitrite and nitrate measurement

A Hanna HI83399–02 spectrometer was used for measurement. A series of Hanna reagents were used, following an adaptation to the Ferrous Sulfate Method, 10 ml of sample are sued for made the measurement and a 1 packet of reactive kit are used for made the reaction, follow the indication of Hanna instrument. The sample catalyzed are diluted 1:100 for made the measurement, blank of reactive are used according to Hanna protocol indication, where the reaction between the nitrite and reagent causes a colour change in the sample. For nitrate, an adapted cadmium reduction method was used. The reaction between nitrate-nitrogen and reagent creates an amber tone in the sample. In both cases, colour intensity is determined via a compatible photometer, and the concentration will be shown in mg/L (ppm) of nitrite or nitrate.

2.5 Nitrogen and phosphorous measurement

A Hanna HI83399–02 spectrometer was used for measurement with biochemical techniques recommended by Hanna Instruments according to U.S. Environmental Protection Agency (EPA) norms. Ten milliliter of sample

are sued for made the measurement and a 1 packet of reactive kit are used for made the reaction, follow the indication of Hanna instrument. The sample catalyzed are diluted 1:100 for made the measurement, blank of reactive are used according to Hanna protocol indication. For nitrogen, the acid chromatographic method was used as an indirect measurement of nitrites and nitrates. For phosphate, an adapted ascorbic acid method was used to estimate phosphorus concentration indirectly. Colour intensity is determined in all cases via a compatible photometer, and the concentration will appear in mg/L (ppm) of different metabolites.

2.6 Data analysis

Data were graphed and treated with statistical normality tests, two-way ANOVA and a Tukey's post-test, using the Prism gradphad program (version 5). Data are presented on average ±, with a $p < 0.5$ considered significant.

3 Results

3.1 Nutrient changes

A catalyzed sardine solution was measured before and after a 12-hour period and showed an increase in nitrites, nitrates, nitrogen and phosphorus, as Fig. 1A shows. The data indicate increased organic matter in the catalyzed solution. The river water was used as a control to measure its parameters and uncatalyzed sardines at 12 hours, as shown in Fig. 1B. The results of this field study present the option of treating the organic matter with a catalyst, thereby generating a fertilizer which can deliver increased organic material to the soil for farming purposes. Figures 1 and 2 show an increase in the NPK profile of the catalyzed mixture, which is transferred to the soil and increases nutrient concentrations.

3.2 Soil changes

Measurements were taken on the land where the catalyzed material was applied to analyze its nitrogen, phosphorus and potassium parameters, as shown in Fig. 2. We can see that organic material parameters increased after using catalyzed material. Non-systematized field reports indicated a lack of foul or loathsome odors detected by health inspectors who came to the farm location (Data reserved by the Farm and Livestock Service), along with improvements of over 90% in the location reported by the fertilizer recipient (Data reserved). These data show that organic material can be quickly catalyzed and used

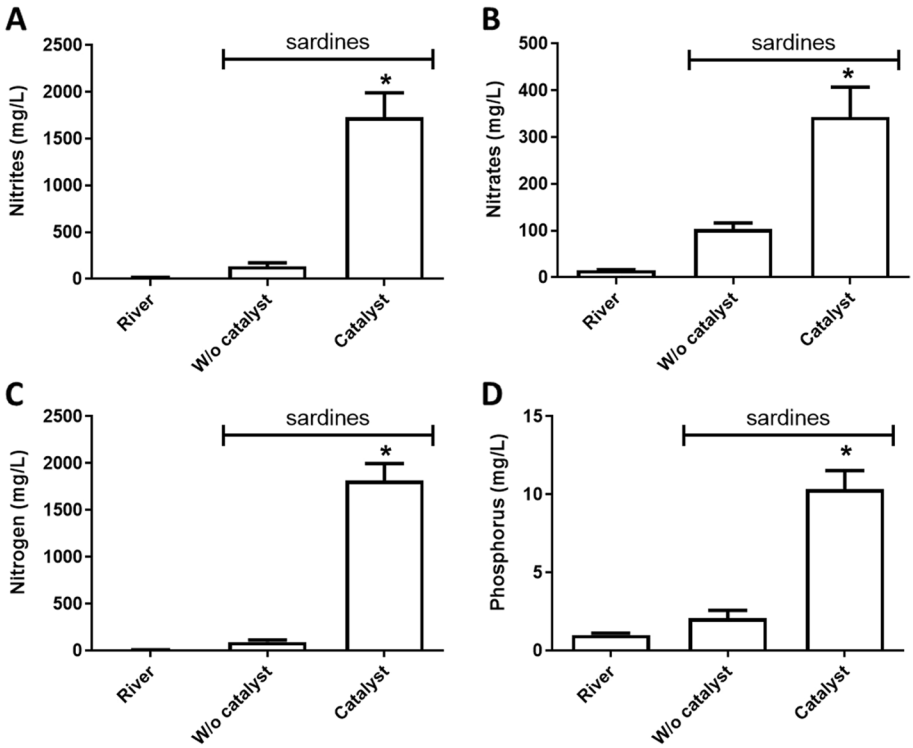

Fig. 1 Effects of applying catalyst on stranded fish. **A** nitrite concentrations in both conditions; **B** nitrate concentrations in both conditions; **C** nitrogen concentration in both conditions; **D** phosphorus concentrations in both conditions. Bars represent the average ± SEM of 3 independent experiments. Asterisk indicates $p < 0.05$ (ANOVA)

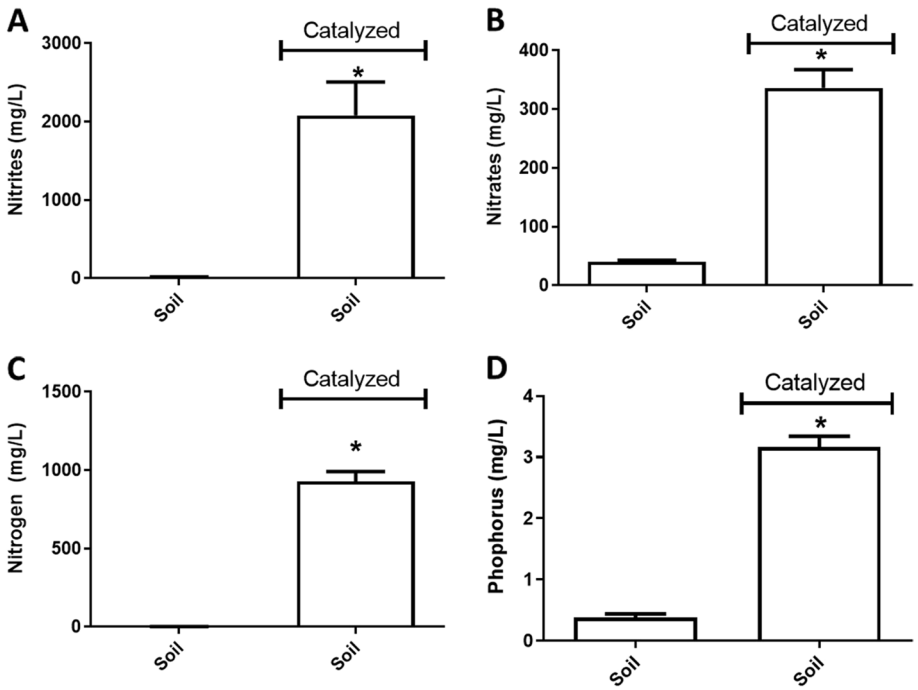

Fig. 2 Effects of applying catalyzed sardines in a farm field. **A** nitrite concentrations in both conditions; **B** nitrate concentrations in both conditions; **C** nitrogen concentration in both conditions; **D** phosphorus concentration in both conditions. Bars represent average ± SEM for 3 independent experiments. Asterisk indicates $p < 0.05$ (ANOVA)

as organic compost, in contrast with traditional composting methods [15], for farming purposes.

3.3 Odor study

An appreciation table was used according to Chilean norms, and a rating was requested from independent observers. Figure 3 shows the intensity of disagreeability for the samples after catalysis compared with the initial and non-catalyzed materials. This case involved a beaching emergency which could be solved in days by delivering a fertilizing solution without odor in alignment with current health norms to use for organic fertilizing, in line with circular economic policies decreed by various ministerial organisms [18].

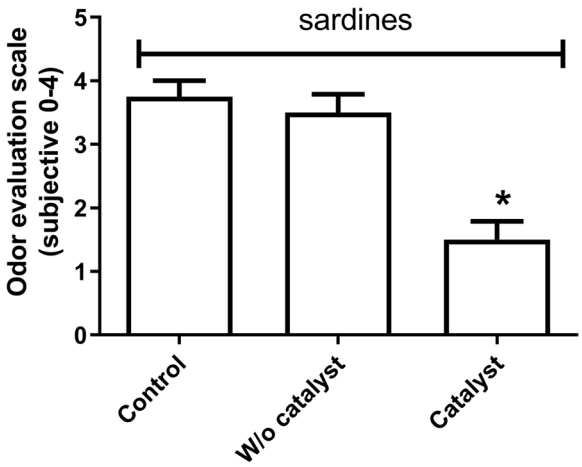

Fig. 3 Graphic representation of smell rating from observers. Representation bars are the average ± SEM of 3 independent experiments. Asterisk indicates $p < 0.05$ (ANOVA)

4 Discussion

The results of this field study present the option of new product for treating the organic matter with a catalyst, TCAS-CATA, thereby generating organic fertilizer, which can directly deliver increased organic material to the soil for farming purposes. The decomposition of this material generated a health problem because the decomposition made volatile acid and generated odor [5]. One way to resolve this problem and produce soil is composting [15],but the composting is process excellent for made soil but have secondary effect [19]. However, using specific protein sources when composting is not recommended due to attracting vectors to the compost bin [15] and presenting a waste management problem, the composting can be part of the solution but here we present a new product for control the waste and generated soil nutrition solution [20]. Our results suggest a new product,

TCAS CATA for present a new process to control organic waste, especially in this emergency. But in the future for other organic wastes the catalyst model compound generated soil nutrients without an odor problem in a short time and resolved the fish stranding problem., not need a composting and all the material are used direct. Figs. 1 and 2 show an increase in the Nitrogen, Phosphorus, and potassium (NPK) from values close to 0 to 2 g/L of nitrogen and 10 mg/L of phosphorous when seeing the profile of the catalyzed mixture, this NPK profile are unique for this wasted and not be considered a fertilizing protocol, because the Figs. 1 and 2 suggest the values of NPK are dependent of the wasted origin. This mixture is transferred to the soil and increases nutrient concentrations, with Fig. 3 showing 1 g/L of nitrogen, for example, this data are relevant because indicate the soil can be recovery when used TCAS CATA and the process described. Non-systematized field reports indicated a lack of foul or loathsome odors detected by health inspectors who came to the farm location (Data reserved by the Farm and Livestock Service, SAG), along with improvements of over 90% in the location reported by the fertilizer recipient (San Osvaldo Farm). Figure 3 shows a subjective odor perception reduction from 4 to 1. These data indicate that organic material can be quickly catalyzed and used as organic fertilizer, in contrast with standard composting methods [15], for farming purposes. This case involved a beaching emergency which could be solved in days by delivering a fertilizing solution, in line with circular economic policies decreed by various ministerial organisms [18]. New studies to observe the effects in other wastes are needed, as well as to establish a concentration-response relation and kinetics, to present a work protocol for these wastes during organic deposition emergencies where they can be used for recovery soil.

5 Conclusion

Our results present the evidence that using a catalyzed sample from fish stranding fertilized the soil with 2 g/L of nitrogen without odor, and nitrogen concentrations in the field increased from values close to 0 to 1 g/L. New studies to observe the effects in other wastes are needed, as well as to establish a concentration-response relation and kinetics, to present a work protocol for these environmental emergencies. Actual, a direct mixture of the organic wasted in a proportion of 2:1 in 1% TCAS CATA solution, for 12 hours are sufficient for generated the catalyst and deliver direct to the soil.

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Authors' contributions
JP designed and did the experiment and wrote the MS; IS reviewed the MS and made the main editing for English; VC helped to do the experiment and write the MS; IV supported the samples and provided space for the investigation. The author(s) read and approved the final manuscript.

Declarations

Competing interests
The authors declare that they have no conflict of interest.

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