0435

Modified Atmosphere Applications in Museums

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Abstract: Historical Palaces in Istanbul (Turkey) are infested with the furniture beetle (*Anobium punctatum*) with the aid of favorable conditions such as high humidity and temperature.

Due to ban of Methyl bromide in Turkey, the furniture beetle disinfestations of wooden historical artifacts have been shifted to use of alternative applications such as modified atmospheres.

In this study, portable wooden artifacts, which have damage risks with the traditional fumigation procedures, were confined in PVC cubes of 30 m^3 volumes to apply with modified atmospheres composed of conditioned high nitrogen ((99%).

Nitrogen gas was obtained using a Nitrogen Gas Generator and a SCADA (supervisory control and data acquisition) system were also set to maintain N_2 concentrations in several PVC units at desired levels during the application period of 30 days.

Results showed that portable PVC modified atmosphere units were effective to retain N_2 concentrations at high levels, and the PLC SCADA system successfully controlled the N_2 levels in several PVC units, and that no insect survived after 30 days of exposure to high nitrogen.

Introduction

A variety of pests inhabit historical buildings & museums (Schrock, 1988) and can cause significant damage to valuable artifacts unless the necessary control measures applied (Reichmuth *et al.*, 1993). The nature of the historical artifacts imply that some traditional chemicals can not be applicable in the historical buildings & museums due to damage risks to the artifacts, and also to environment and to operators (Dawson, 1988; Florian, 1998).

Modified atmosphere applications, on the other hand, offer effective pest control approaches in various environments including museums, and do not pose the major risks mentioned above (Bailey and Banks, 1980; Daniel *et al.*, 1993; Gilberg, 1989; Navarro, 1978; Reichmuth *et al*, 1993, Rust and Kennedy, 1993; Zycherman and Schrock, 1988)

Turkey has a lot of historical palaces/pavilions which subject to damage by wood pests. Of these, 12 Ottoman palaces/pavilions in Istanbul serve as museums under the administration of Department of National Palaces of Turkish Grand National Assembly. Wooden structural parts and/or wooden artifacts of those palaces have been continuously damaged by *Anabium punctatum* De Geer in the lack of necessary control mesaures throughout the many decades.

The importance of the damage caused by the pests to Ottoman Palaces has led to formation a project which financially supported by SPO (Turkish Republic Prime Ministry State Planing Organization) in 2003. In the framework of that project transportable wooden artifacts of Ottoman Pavilions were fumigated on site by means of modified atmospheres applied in PVC envelopes (cubes). This communication gives information on the application of modified atmosphere in Ottoman palaces against wood – boring insects.

Materials and Methods

Test Insects

Despite our several attempts we could not provide live insects from different laboratories. Thus, wood pieces showing live *Anobium punctatum* larval activity taken from the restoration department were used as infested materials. The other test insects were some of the well known stored product insect (Table 1.) Test individuals are gently placed in special PVC vials of 10 – 20 mL volume whose lids fitted with very fine wire mesh of diameter of 1 cm to prevent the escape of insects and to ensure air passage.

PVC Cubes

Modified atmosphere applications were made in 18 PVC cubes of 30 m^3 volume each. These cubes were originally designed for toxic gases or carbon dioxide fumigations, especially in the food and agriculture industry. However we have tested and developed a protocol to maintain a low oxygen atmosphere of 1% in the

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cubes by the Scada system. The cube which also has an internal frame of galvanised pipe(id, 2.5 cm) were composed of a bottom floor and a top cover part which were joined together with a PVC tongue – & – groove zipper after filled with artifacts. For gas flushing, cubes were provided with inlet and outlets openings at opposite directions, which can be closed by means of gas tight screw lids.

Modified Atmosphere Treatments

Low oxygen atmospheres composed of high nitrogen gas were obtained using a nitrogen gas generator(On Site Gas Systems, Inc., USA) of 4 Nm^3/h outlet flow capacity. Nitrogen gas obtained from the gas generator was humidified at ambient Rh and conveyed to each of the 18 pieces of PVC cubes. A PLC Scada system was also set up to restore nitrogen levels in different cubes when the oxygen level increased above 1%. The cubes were initially flushed with a high flow rate(30 m^3/h) of nitrogen using liquid nitrogen dewars of 240 L capacity to shorten the gas pushing time and when the oxygen level inside the cubes dropped below 3%, nitrogen gas generator with the PLC Scada system was run to get a further reduction to 1%. The oxygen concentration, relative humidity, and temperature in the cubes were continuously monitored. Treatments were continued 30 days.

Table 1. Numbers and the ages of insect species according to the developmental stages used for modified atmosphere applications.

Insect species	Developmental stages			
	Eggs	Larvae	Pupae	Adult
Tribolium castaneum	1 – 3 d(50)*	Mature (25)	1 – 3 d (15)	5 – 10 d (25)
Tribolium confusum	1 – 3 d (50)	Mature (25)	1 – 3 d (15)	5 – 10 d (25)
Trogoderma granarium	1 – 3 d (50)	Mature (25)	1 – 3 d (15)	5 – 10 d (25)
Rhyzopertha dominica	1 – 3 d (50)	Mature (25)	1 – 3 d (15)	5 – 10 d (25)
Infested wood pieces	wood materials showing insect activity			

* Number of the test individuals

After the treatments, test insects in special enclosures were returned to laboratory and counts were made to check the mortality. Wood pieces showing insect activity were also kept at the laboratory in special PVC boxes to observe any insect activity.

Results and Disussion

Temperature and relative humidity data measured inside the cubes during 30 days of exposure were shown in Figure 2. Oxygen concentrations were between 1% – 1.5% throughout the treatments (Fig. 3). Mortality records showed that all the test insect were killed by the treatments of high nitrogen. Similarly, infested wood pieces with *Anobium punctatum* which separately kept in plexiglas containers after the treatment did not show any larval activity during 2 years after the treatments(Table 2).

Based on data presented by Frank(1991) and Reichmuth *et al.* (1991), Reichmuth *et al.* (1993) informed that some wood – boring pests including *Anobium punctatum*, *Hylotrupes bajulus* L., and *Lyctus brunneus* Stephens were completely killed for up to 35 days at the temperatures ranging from 16 to 35℃. They also report that at 16℃, adults (separate), eggs (in wood and separate), and larvae(in wood) of Anobium punctatum were completely killed in 35 days. Similar results were obtained with other wood – boring insects. Valentin(1990) showed that exposures to 1.0% O_2 atmospheres for 20 days killed deathwatch and powderpost beetles (Rust and Kennedy, 1993). Gilberg(1989) reported that, insect pests frequently encountered in museums, 7 day exposures at 30℃ and 65% – 70% RH to 0.421% O_2 in nitrogen killed webbing clothes moths, cigarette beetles, drugstore beetles, carpet beetles and powderpost beetles(Rust and Kennedy, 1993)

In conclusion, low oxygen atmosphere using high nitrogen in PVC cubes offer safe and efficient control of pests of wood in artifacts preserved in museums.

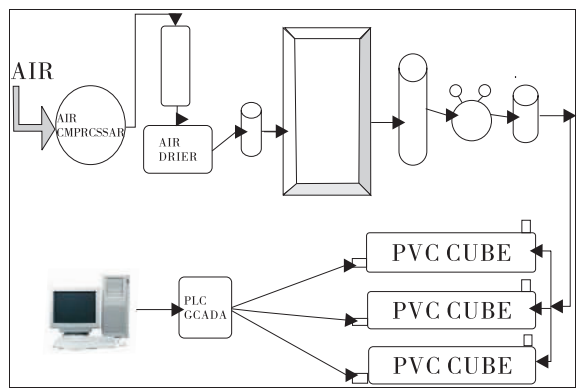

Fig. 1 Modified atmosphere fumigation system design

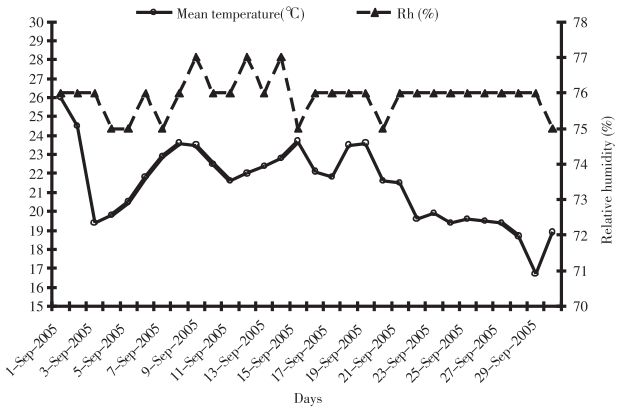

Fig. 2 Daily mean temperature(℃) and Rh(%) data recorded inside the cubes during the modified atmosphere treatments

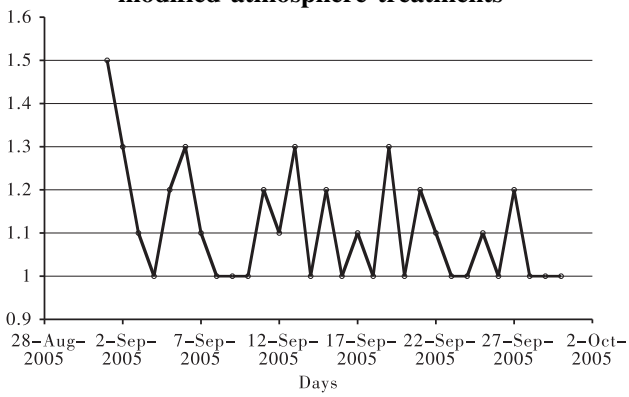

Fig. 3 Daily mean oxygen level(%) recorded inside the cubes during the modified atmosphere treatments.

Table 2. Mortality of the life stages of test insects during modified atmosphere treatment(%)

Insect species	Developmental stages			
	Eggs	Larvae	Pupae	Adult
Tribolium castaneum	100	100	100	100
Tribolium confusum	100	100	100	100
Trogoderma granarium	100	100	100	100
Rhyzopertha dominica	100	100	100	100
Wood pieces showing insect activity	No insect activity was observed during 2 years after the treatments			

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