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From wood pellets to wood chips, risks of degradation and emissions from the storage of woody biomass – A short review



Esa Alakoski^{a,b,*}, Miia Jämsén^{a,b}, David Agar^c, Elina Tampio^b, Margareta Wihersaari^{b,d}

^a JAMK University of Applied Sciences, Institute of Bioeconomy, Tuumalantie 17, FI-43130 Saarijärvi, Finland

^b Department of Biological and Environmental Science, University of Jyväskylä, P.O.Box 35, 40014, Finland

^c Department of Chemistry, University of Jyväskylä, P.O.Box 35, 40014, Finland

^d Åbo Akademi University, Strandgatan 2, FI-65100 Vaasa, Finland

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ABSTRACT

The compounds in stored woody biomass degrade as a result of chemical and/or biological processes during storage. These processes produce gaseous emissions. Recent studies concerning gaseous emissions from wood pellet storages are reviewed herein. The applicability of the results from pellet research to wood chips is discussed. Thorough scientific understanding on the storage phenomena of wood chips is extremely important as the threat of climate change and the need to reduce greenhouse gas emissions have led to an increased need to large scale wood chip storage to ensure supply. Typically the gases produced from stored woody biomasses are carbon monoxide (CO), carbon dioxide (CO₂), methane (CH₄), and other volatile hydrocarbons e.g. aldehydes and terpenes. CO₂ and CH₄ are greenhouse gases with high global warming potential. Chemical degradation via auto-oxidation of fats and fatty-acids seems to be the dominant mechanism for off-gassing from stored wood pellets, whereas biological processes are mainly responsible for the gaseous emission from wood chips. In confined storage spaces gaseous emissions may lead to oxygen depletion. Oxygen depletion together with a high CO concentration poses a serious health risk for those working in such conditions. The degradation processes also result in dry matter losses and in spontaneous heating and in the worst case, especially in large piles, spontaneous ignition of the stored material. Thorough and systematic scientific studies on degradation processes and their effects are needed in order to understand and minimise risks from large scale wood chips storage to human health, environment and property.

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* Corresponding author at: JAMK University of Applied Sciences, Institute of Bioeconomy, Tuumalantie 17, FI-43130 Saarijärvi, Finland. Tel.: +358 50 360 1968; fax: +358 14 260 2321.

E-mail address: ealakosk@gmail.com (E. Alakoski).

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1. Introduction

The threat of climate change and the need to reduce greenhouse gas emissions have led to an increase in the demand and use of biomass in energy generation. In order to ensure supply, this means increasing in the amounts of biomass in storage for extended time periods. In areas with high heating demand during winter time e.g. in the northern coniferous forest belt this typically means woody biomass such as stem wood, wood chips and wood pellets.

Gaseous emissions are produced during storage of woody biomass [1–3]. The gases produced are typically greenhouse gases and present serious risks for people entering enclosed storages. Chemical and biological degradation processes are responsible for these emissions. The processes leading to gaseous emissions also produce dry matter losses, deterioration of mechanical properties and spontaneous heating in the stored material [4–6]. These processes and their effects need to be thoroughly understood in order to minimise the risks produced.

During the last fifteen years wood pellet production, storage and use has seen a rapid increase. Some serious accidents with fatalities have also happened in pellet storages [7,8]. Preventing such accidents from happening has been the main motivation of several studies on gaseous emissions (off-gassing) from wood pellets [1,2,9]. On the other hand, similar studies on gaseous emission from stored wood chips are almost non-existent. Fears of fire hazards from spontaneous heating in the stored material and of dry matter losses are currently the main factors limiting the storage of wood chips in large piles. Herein it is postulated that as both pellets and chips are produced from woody biomass the phenomenology during storage of both is similar and therefore significant insight to wood chip storage phenomena can be gained by considering pellet studies. This paper reviews pellet off-gassing studies and tries to reflect on the similarities in wood pellet and wood chip degradation phenomena. The purpose of this work is to provide a foundation for further research on the degradation processes on-going in wood chip storages. The ultimate goal of such experimental research is the development of new and safe methods to store wood chips in large piles for extended time periods.

2. Wood pellet storage

2.1. Storage halls and silos

Pellets are stored in halls and silos so that a year-round supply of fuel for consumers can be secured. Wood pellets are stored indoors in dry conditions as they absorb moisture rapidly. After production, pellets are stored at production facilities before transporting to customers for storage and use. Large-scale users,

such as municipal heating companies and housing co-operatives, usually store their pellets in large silos. Small-scale users store pellets in their domestic storage rooms or smaller silos.

Storage time typically varies along with heating demand. In summer, when the heating demand is low, pellets are stored for longer times at production facilities and intermediate storages [10]. Longer storage times and the fact that the amount of gaseous emissions tends to be enhanced immediately after pellet production mean that the bulk of storage emission is produced in these locations. During winter the heavy heating demand leads to shorter storage times at production facilities and intermediate storages and increased emissions at user facilities [1]. One important growing industry with increasing interest in cheap and renewable energy heating systems in winter time is year around greenhouse farming [11].

Degradation processes induce heating in pellet piles during storage and produce gaseous emissions [2,3,9,12,13]. These processes may lead to reduction of pellet quality and dry-matter losses. At least two fatal accidents have occurred in pellet storages in Finland in recent years. In both cases a storage silo employee died from carbon monoxide poisoning [7]. In addition spontaneous heating resulting from degradation processes take place in pellet silos and this combined with the presence of wood dust can be a fire hazard [14,15].

2.2. Storage during transportation

Typically trucks are used for shorter distance and trains for longer distance land transportation of pellets [16]. Transportation distances e.g. in British Columbia, Canada are up to 150 km by truck from a pellet mill to a railhead and nearly 800 km by railway to port for overseas shipping [17]. Since 1997 pellets have been transported from Canada to Europe by using marine vessels. The longest transportation distances are from the west coast of Canada via the Panama Canal and across the Atlantic Ocean to Sweden. The journey takes about seven to nine weeks. More than one third of the energy consumption of the pellet production and transportation process is caused by intercontinental transportation with marine vessels [17]. A rising new pellet market in the Far East is supplied from Canada via the Pacific Ocean. Shorter transportation distances lasting from 24 h and upwards are used e.g. in the Baltic [8]. Typically long distance freighters have up to ten cargo holds per vessel and each of them can hold approximately 3000 t of wood pellets. The cargo hatches are kept closed during sea voyages [18].

Off-gassing from pellets during transportation poses a serious occupational health hazard. The risks are high especially for people working with marine shipments as storage for extended periods in enclosed holds leads to accumulation of gases emitted from pellets. Typically accidents happen in ports during unloading of pellet shipments due to harmful gases that have leaked from cargo

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