Modern Environmental Science and Engineering

Volume 3, Number 9, September 2017

Academic Star

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Database Index:

Modern Environmental Science and Engineering (ISSN 2333-2581) is indexed by SSRN, CrossRef and Ulrich now.

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Modern Environmental Science and Engineering

Volume 3, Number 9, September 2017

Contents

Technical Papers

601 **Urban Development of the Subsurface: Sketches from Switzerland**

Alexander Ruch

614 **Leachate for Producing 3rd Generation Microalgal Oils**

Zareen T. Khanzada, and Süleyman Övez

625 **The Perception of Green Building Index Facilitator towards the Traditional Malay House Sustainability**

Wan Mohd Fakhzan Wan Zakaria, Mawar Ahmad, and Mohd Zulkarnain Salehudin

632 **Ecological and Chemical Analysis of Heavy Metal Transduction in *Salix exigua* on the Animas and Florida Rivers**

Magena Marzonie, Cynthia Dott, and Callie Cole

644 **Measurement of the Heat Transfer Coefficient in Case of Impinging Synthetic Jet**

Petra Dancova, Tomas Vit, and Jan Novosad

653 **Afforestation with the Purpose of Restoring the Protected Natural Area "Cerro del Punhuato", Morelia, Michoacán**

Marcial Reyes Cázarez

661 **Weed Vegetation around Red Dragon Fruit Plants: *Hylocereus polyrhizus***

Retno P. Sancayaningsih, Wilhelmus T. A. Sanjaya, W. Supriyanto, Ilham M. Laksono, and Devi A. Shara

667 **Genoa in the Second Part of XX Century: An Analysis through Contemporary Migrations**

Enrico Bernardini

Modern Environmental Science and Engineering (ISSN 2333-2581)
September 2017, Volume 3, No. 9, pp. 601-613
Doi: 10.15341/mese(2333-2581)/09.03.2017/001
Academic Star Publishing Company, 2017
www.academicstar.us

Urban Development of the Subsurface: Sketches from Switzerland

Alexander Ruch
ETH Zurich, Basel, Switzerland

Abstract: The space which cities need to develop is limited. People's demand for space to live and work in and generally enjoy is growing all the time (the amount of settled space in Switzerland increased twice as fast as the population between 1985 and 2009: at 23% compared with 11% (BFS: Die Bodennutzung in der Schweiz, Resultate der Arealstatistik [Ground Use in Switzerland, Results of Land Use Statistics]). In addition, immigration is on the rise, traffic requires ever more space, and pollution — particularly as a result of noise — is increasing exponentially, while the loss of land available for agriculture and the destruction of the landscape call for the spread of settled space to be curbed, for density and concentration, and for an emphasis on working inward and even downward when developing land for settlement. The city needs to use the space the subsurface offers for its development. The areas of the subsurface that might be used for construction are also associated with usable rock, geothermal energy, and drinking water.

Policy is little concerned with using the subsurface, urban planners are not familiar with it or its potential for urban development, the lack of geological expertise regarding the subsurface can result in damage (see section 4.4 below concerning StaufenimBreisgau), and spatial planning and related law pay scant attention to it as well. Any use made of it tends to be uncoordinated. This results in conflicts over use, and there is a growing danger the potential of the subsurface will not be fully exploited. The subsurface needs to be factored into spatial planning at all "levels" without exception, and particularly into planning in relation to urban development.

There is a lot of talk about three-dimensional urban development, but this is about applying the methods and instruments associated with (spatial) planning beyond the space at and above the surface and putting them to productive use for the underground dimension of space too. It is a case of ascertaining how far the law needs to concern itself with urban planning in relation to the subsurface, how well the existing instruments associated with spatial planning address the specific issues of using the subsurface, and to what extent special regulations regarding the subsurface are required at the various levels of planning. Other questions include how the various demands for use might be coordinated, to what extent the need for an overview calls for a new methodology, how far the law concerning the limits of land ownership and delimiting responsibilities and interests as regards use of the subsurface remains adequate, and whether 3D surveying provides sufficient support. These and similar issues will be addressed in the rest of this document, with special reference to the situation in Switzerland.

Key words: spatial planning, subsurface use, 3D cadastre, conflicts over use

1. Introduction

Demands to use the subsurface are growing all the time. The competition is diverse. In one and the same area, one party wants to use geothermal heat, another wants to lay a gas pipe, and a third hopes to build a tunnel, while all the various landowners would like heat from the groundwater too. Until now, use of resources in the subsurface has been uncoordinated, leading to conflicts over use and a danger the potential below ground may not be appropriately exploited. It cannot be right, however, to adopt a "first come, first served" attitude. Rather, all activities must be coordinated, as we are used to doing at the surface. The spatial planning phase — which is now indispensable — comes with a caveat in planning terms (no activities that impact on space without planning), and this in turn places a planning obligation on the authorities [1].

Corresponding author: Alexander Ruch, Dr., Professor, Lawyer; research areas/interests: spatial planning law, environmental law, technical law. E-mail: ruch@recht.gess.ethz.ch.

The remainder of this document begins by highlighting the various types of subsurface use and the responsibility for regulating such use (section 2). This is followed by a discussion of a number of legal aspects (e.g., land ownership rights, authorizations/permits, regulations on use) (section 3). The last part outlines how planning works in relation to subsurface use (section 4).

2. Types of Subsurface Use and Responsibilities for Regulating Such Use

According to Swiss federal law, the cantons — i.e., the member states of the Swiss Confederation — are responsible for legislation in all matters not assigned, under the Federal Constitution, to the Confederation for it to legislate on. As such, there are no areas where neither of the two levels of government is responsible for legislation. Where the intention is to pass responsibilities to the Confederation, the Federal Constitution needs to be amended for each individual matter.

In Switzerland, the main distinctions are made between the following types of subsurface use [2-4].

2.1 The Subsurface as Somewhere to Build

The subsurface helps to anchor both buildings erected above ground (their foundations provide support and secure everything in place and also provide a shell for settlement activities) and structures created below ground (bridges, road tunnels, underground railroads, etc.), as well as serving as somewhere to run all kinds of pipelines. Stories below ground level have the advantage of being isolated from climatic influences and noise and being out of sight, although they do miss out on natural light, which makes them unsuitable as spaces where people need to spend long periods of time (somewhere to live or work). Having said this, there are also numerous buildings at the surface where there is often no natural light (particularly in shopping malls). The employees concerned are given so-called light breaks so they can "top up" on daylight and enjoy unrestricted views for a certain time (currently 20 minutes every half day) in the interest of their health (art. 15 of the guide to Ordinance 3 relating to the Swiss Employment Act of November 2016). In principle, any uses which are not permanently reliant on daylight can be moved to the subsurface, leaving the space above ground free for other uses — such as accommodation, offices, relaxation areas, and urban spaces.

As a rule, stories below ground are not subject to provisions regarding minimum distances between things or limits imposed on the height or depth of structures, as is the case for buildings above ground. This basically means there are no limits to the horizontal and vertical dimensions of stories below ground, although in terms of public law, this may be opposed by legal regulations regarding either the protection of trees or groundwater. Groundwater protection in particular needs to be considered from many different aspects. For example, it governs the extension of underground structures in both a horizontal and vertical direction, thereby limiting the number of stories below ground, and imposes criteria for the arrangement of culverts (i.e., the pressurized pipes which help groundwater overcome obstacles).

Further limits to ground used for construction also need to be considered. For one thing, the subsurface just below street level contains utility and communication networks. So it is a case of considering the urban context and the characteristics of the specific location where underground structures are to be built, as well as the acceptability of uses of the space below ground in urban areas. These are also connected to the geological and hydrogeological conditions at the site. Much importance here is attached to the techniques applied in the construction of underground works. And ultimately, cost is another criterion when deciding whether to build below ground.

In the subsurface, where daylight may not necessarily be needed? The Balestra multi-story car park in Lugano, with its eight stories for parking and its

overall volume, takes up a very large amount of space above ground that could be better used for residential and work purposes. On the other hand, the geological and hydrogeological conditions may mean there is not enough space to accommodate this kind of volume in the subsurface. And it is ultimately no small thing that a structure which succeeds in architectural terms can really add to the urban landscape, even if it is "only" a humble car park.

Motorized traffic is claiming an ever increasing amount of space below ground, which can also help relieve some of the pressure on the city above ground and the space above ground in general. Much of the traffic skirting around or passing through cities is diverted through tunnels. In some cases, it is deemed appropriate to divert goods traffic in particular, and the bulky carriers used, through the subsurface. The recently launched *Cargo sous-terrain* (Underground Cargo) project intends to relieve the pressure on roads and railway routes by using an underground tube with permanently self-driving vehicles to transport goods.

Goods traffic is to be diverted below ground, with unmanned carriages transporting standardized pallets along three-lane tunnels 24 hours a day. The tunnels containing the tubes will run at a depth of 20 to 50 m and be around 6 m in diameter. The tubes will contain three lanes: one for either direction, and a service lane in the middle. The vehicles are to be propelled and steered by electromagnetic induction. Power is conducted down lines in the floor of the tunnels.

Fig. 1 Balestra multi-story car park in Lugano (photograph: A. Ruch).

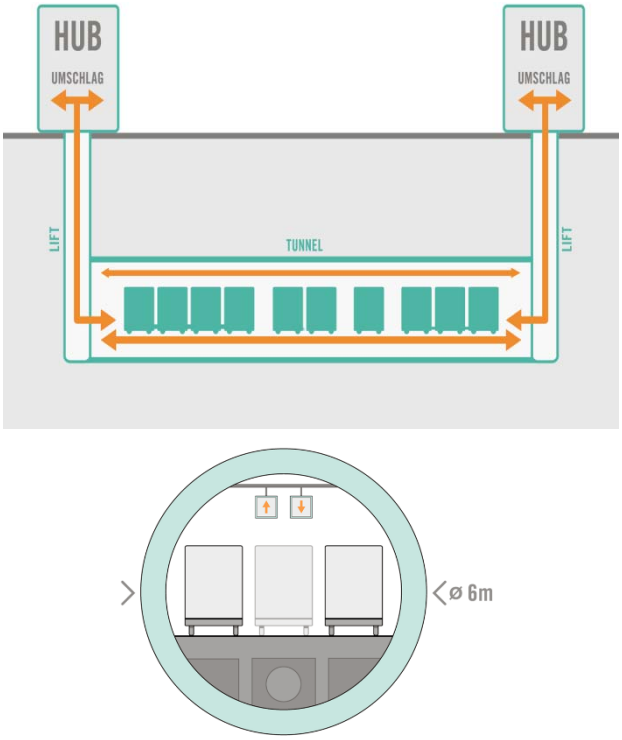

Fig. 2 Underground Cargo, longitudinal and cross section.

Regulation of subsurface use for construction purposes is a matter of construction law and therefore a job for the cantons. The Confederation does, however, have some sectoral authority in terms of construction law, particularly in relation to classic infrastructure elements such as railroads, freeways, airports, energy supply facilities, and telecommunications, where the Confederation grants the relevant permits. Then there are a number of federal laws that contain provisions relating to construction law that must be applied when making any decisions in the area of construction law. These include environmental law and the law regarding groundwater protection in particular.

2.2 Subsurface Use for Disposal Purposes

Subsurface use for disposal purposes is less of an issue these days in urban areas. It is only referred to here for the sake of completeness.

Regulation of subsurface use for disposal purposes is the responsibility of either the Confederation or the cantons, depending on the matter involved. For example, the Confederation is responsible for waste

facilities and the storage of radioactive waste, while legislation on CO_2 storage is a matter for the cantons. It would be fair to say the Confederation is responsible for the framework legislation on environmental and groundwater protection and that uniform provisions apply across Switzerland in these areas.

2.3 Procurement of Raw Materials

Unlike the two types of subsurface use described above, the procurement of raw materials highlights the natural properties of the subsurface. It is not a case here of developing space for human activities, but of exploiting the internal elements of the subsurface. Raw materials are simply there — without humans having to do anything. This particular piece is concerned with those raw materials (geomaterials: rock and earth) which are needed in cities (these are also mined in urban areas in some cases). These are mineral materials used as granular matter in the manufacture of concrete and asphalt, materials for the manufacture of gypsum and cement, natural rock for buildings above ground, and debris for road building. Ever more geomaterials are being used for construction purposes, which need to be transported from ever further away. High-quality hard rock can be found in a narrow band between Lake Constance and Lake Geneva and often lies in protected landscapes [5]. As such, there is a growing need to tap into new gravel stocks and open up new quarries, which points to conflicts with other uses and competing demands for use [6].

Regulation of the procurement of geomaterials, particularly quarries and gravel pits, falls within the authority of the cantons [7]. The Confederation has no authority to issue any binding provisions.

2.4 Storage and Use of Groundwater

Groundwater is also a raw material, but its special significance and the diverse ways it can be used deserve to be described separately. There is sufficient groundwater of good quality almost everywhere in Switzerland. In urban areas, however, it may also contain undesirable foreign matter (e.g., VOCs, particularly tri- and tetrachloroethylenes/solvents, PFCs from the drains in settled areas, gasoline additives used as antiknock agents, medicines) (for more information regarding such problems, see the publication by BAFU titled Ergebnisse der Grundwasserbeobachtung Schweiz NAQUA; Zustand und Entwicklung [Results of Groundwater Monitoring for Switzerland NAQUA; Status and Development] 2004-2006, 3/09, p. 62). And urban areas tend to leave something to be desired in terms of groundwater protection [8]. The ground, whose layers protect water, plays an important role in the quality of groundwater.

Over 80% of Switzerland's drinking water is obtained from groundwater. Groundwater is also used for extinguishing and industrial purposes in urban areas. And it is increasingly being used as a source of energy. Groundwater is used to generate heat too, but unlike geothermal energy, heat is drawn directly from the groundwater itself propelled by groundwater heat pumps (direct thermal use).

Regulation of groundwater is solely a matter for the Confederation. It has had the authority to issue legislation on groundwater protection since the start of the twentieth century, and the relevant act with its detailed ordinances (secondary legislation by the national executive) is already the third comprehensive act passed in relation to groundwater protection. Drinking water is considered to be a foodstuff, an area where the Confederation also has sole responsibility for legislation. The Confederation has issued framework provisions for the protection of groundwater in planning terms, while implementation of plans is a job for the cantons.

2.5 Subsurface Use for Obtaining Geothermal Energy

Use is made of the geothermal heat stored in the subsurface. Heat increases with depth, with a distinction (still) generally made between shallow and deep geothermal energy. This distinction relates to what is possible in technical terms. For the purposes of

the matters discussed here, this distinction will be ignored [9]. Shallow geothermal energy covers depths down to 400-500 m. Heat is drawn from groundwater using geothermal heat probes, ground heat exchangers, geothermal baskets, energy piles, and similar thermoactive elements (for information on indirect thermal usage, see the publication by BAFU entitled Wärmenutzung aus Boden und Untergrund; Vollzugshilfe für Behörden und Fachleute im Bereich Erdwärmenutzung [Using Heat from the Ground and Subsurface; Implementation Guide for Authorities and Specialists in the Field of Geothermal Heat Use] 10/09, p. 18; and by CHGEOL entitled Die Nutzung des geologischen Untergrunds in der Schweiz; Empfehlungen des Schweizer Geologenverbands zur Harmonisierung von Verfügungshoheit, Sachherrschaft und Nutzungsvorschriften [Use of the Geological Subsurface in Switzerland; Recommendations from the Swiss Association of Geologists on the Harmonization of Rights of Disposal, Physical Control, and Provisions Relating to Use]). Shallow geothermal energy is of significant importance in cities, particularly for single-family dwellings and smaller buildings in peri-urban areas.

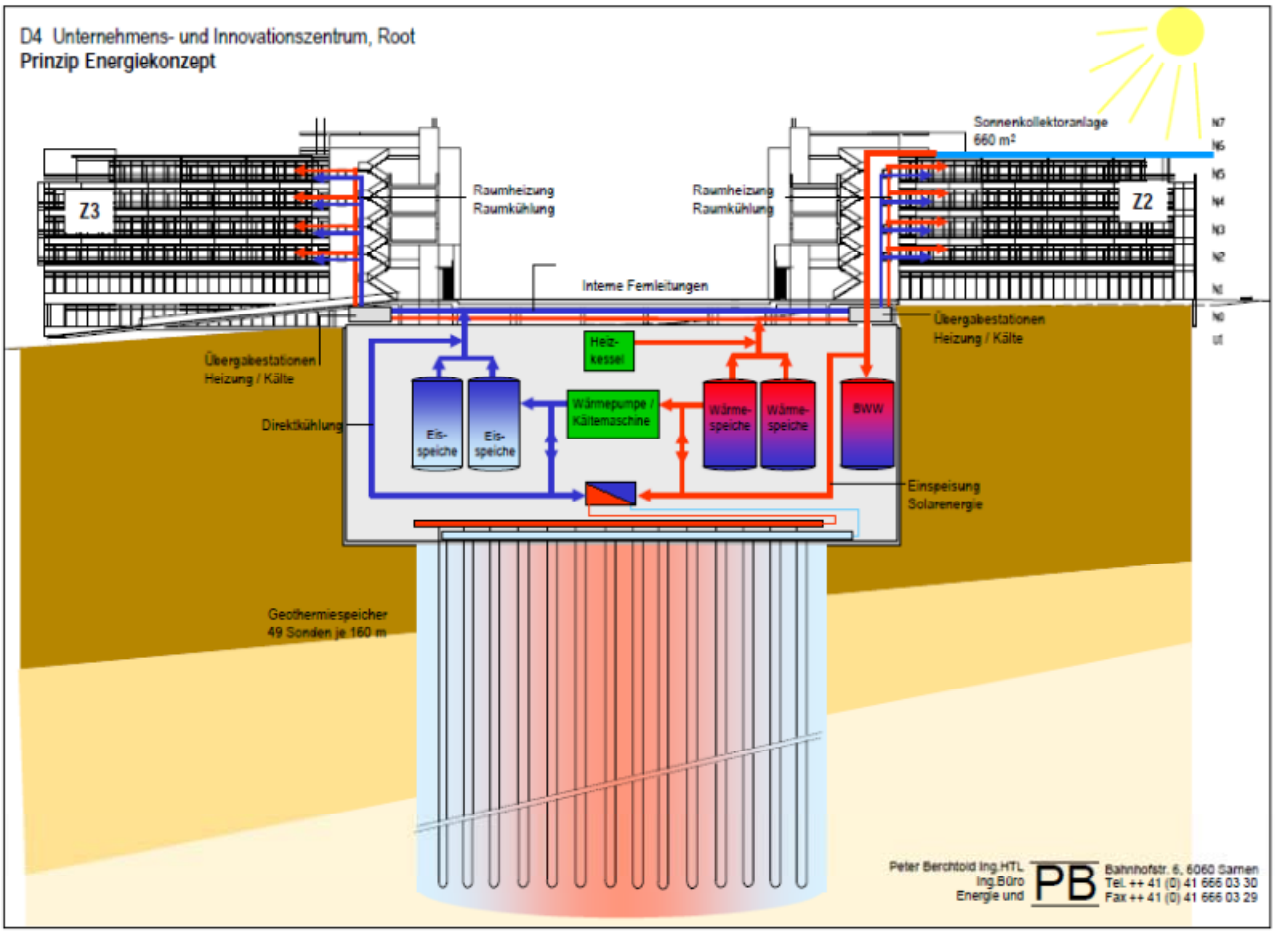

Fig. 3 Energy strategy, soil as a store of solar heat? (Florian Rusch, *3rd Swiss Conference on Solar Heat,* November 12, 2014).

Geothermal energy from greater depths is also suitable for providing buildings with heat. It has an important role to play in intelligent approaches to urban energy supply. Following initial drilling in 1988, geothermal heat from an aquifer at a depth of around 1,500 m has been used at Riehen near Basel for 20 years. In densely settled areas, groups of buildings are supplied from surrounding thermal fields, each of which is connected to a network (GeoDH report: European Geothermal Energy Council, Developing

geothermal district heating in Europe, 2014, February 23, 2015, p. 12).

The possibility of conflicts with other subsurface uses is very high and increasing. Deep geothermal energy, which can be used to generate heat and power, is somewhat different. Although it does also have a role to play for urban areas (apart from Basel, see also the revived project in Zurich's Triemli district), the installations concerned are less significant in numerical terms.

Regulation of geothermal energy is a matter for the cantons. It is worth noting in turn that specific federal laws also have to be applied to decisions relating to geothermal energy projects, particularly in terms of the law regarding groundwater and environmental protection.

3. The Law Governing Subsurface Use

3.1 Land Ownership Rights and Rights of Use

Two categories of parties with rights of disposal are competing for the subsurface: the landowners, whose right of disposal also extends downward, and the "public authorities", who have right of disposal over those areas that do not count as landed property. For the purpose of delimiting things, it is a case of ascertaining how far (private) landed property extends and the depth below which the canton enjoys sovereignty in terms of use. If there are plans to route a railroad tunnel under a built-up area, the construction company will want to know whether the tunnel will need to make use of private landed property and whether disputes with landowners will arise, while the landowner will want to know whether it can now build its geothermal heat probe without further ado or will have to wait for the disputes mentioned to play out.

The limits of a plot are defined horizontally by markings and the entries made in the land registry plans on the basis of official surveys. The relevant limit applies until it is amended by virtue of some formal procedure. Things are rather different as regards the vertical. Landed property extends as far down (and up) as the landowner has an interest to exercise; i.e., it does not extend to center of the earth as is the case in other countries. This is governed by art. 667 para. 1 of the ZGB (which means private law at federal level determines how far landed property extends). Anything beyond these areas of interest or control falls within the (legislative) sovereignty of the cantons. The peculiar thing about landed property and depth is that any limits are not plot-specific but essentially remain open, with the extent of land ownership varying with the intentions of the respective landowner, so are therefore dynamic and cannot be delimited on a permanent basis [10, 11]. The relevant specific interest of the landowner may extend no further than the basement, although it may extend to four underground parking stories or incorporate heat probes of different horizontal and vertical reach.

The idea of an interest to exercise [3, 11] has both a positive and a negative side. On the positive side, it must be actually possible for the landowner to exercise the specific use in question; it must have control over the space and be able to exercise the authorizations for use associated with the landed property "without any particular difficulties or excessive effort" (BGE 93 II 170, 1967, p. 176 E. 5). On the negative side, third parties may only exercise rights of use insofar as these do not undermine the positives aspects of the landed property. This concept of landed property definition has a demarcation role (BGE 119 Ia 390, 1993, p. 398 E. 5c/bb). For example, art. 664 para. 1 of the ZGB stipulates that ownerless and public objects — to which the subsurface is also allocated — come under the sovereignty of the state in whose territory they are located. The "state" in this context refers to the cantons. This means the cantons can assert their right of disposal on the subsurface, providing landed property, as defined under civil law, is not affected as a result. Beyond the "sphere of interest" of landowners, there is no private landed property. Priority is given to the public realm (primacy of the public sphere; BGE 119 Ia 390, 1993, p. 399 E. 5d). "Sovereignty" also means the

cantons can stipulate the type of use. They enjoy a monopoly position in relation to the pursuit of economic activities involving the subsurface as just outlined (see also the end of section 3.3).

3.2 Peculiar Aspects of the Legal Concept of the Subsurface

There is no legal definition of the subsurface in federal law. A look through the cantons' collections of laws reveals, for example, that the applicable law in the canton of Aargau, from June 19, 2012, regarding use of the deep subsurface and procurement of natural resources in the ground rules as follows: "Use of the deep subsurface is understood to mean underground uses that do not involve landed property protected under private law" (section 2 para. 2). The model law for the cantons of northeastern Switzerland, from December 2, 2013, regarding use of the subsurface sets out the following: "The subsurface is deemed to be that part of the earth's interior which is not covered by civil law at federal level" (section 2 para. 1). In decrees issued under public law at canton level, such as the two referred to, there is clearly a trend toward understanding the subsurface to be only what lies below the earth's surface, beyond landed property protected under private law, and can be governed by public law [12]. There is no uniform legal definition of "subsurface".

In construction law, "underground" does not simply mean "covered with earth"; what matters is the ground under which the underground structure is situated. In general, the decisive factor here is natural ground (verdict B 2011/77 by the Administrative Court of the canton of St. Gallen from March 20, 2012, E. 4.2, with reference to individual communal laws whereby the decisive factor is ground that has been shaped and filled).

3.3 Authorizations: Types and Responsibilities

Two types of authorizations apply here: construction permits and licenses. All structures and facilities may only be created or modified across Switzerland with official permission in accordance with the relevant provision of federal law. It makes no difference whether the builder involved is a private individual or a community. Official permission is required not only for actual building work in the subsurface, but also cables, facilities for generating heat, pits, drilling work (including test drilling), and seismology surveys. No distinction is made between permanent or temporary installations. Permission is broadly referred to as a construction permit. And this is also what is meant where cantonal laws give different names to specific types, such as when permission for a geothermal heat probe/heat pump facility or permission for facilities in areas with usable groundwater stocks are referred to as a water protection permit (because water protection law is at the heart of the matters under consideration) [13]. The construction permit does not give the owner any new rights, but only allows him to build and operate the structures.

The use of raw materials and the like requires a so-called license, up front, in addition to the construction permit for the facilities. It represents a conferring of rights, i.e., it gives the recipient the right of use. This is protected by the guarantee of the right of ownership, so can only be withdrawn or diminished by means of expropriation. The holders of any right granted are the cantons (see the last sentence of section 3.1 above), and they are able to exercise it themselves or grant it to third parties.

3.4 The Subsurface As Somewhere to Build

Various sets of laws apply here. Priority is given to spatial planning and construction law at canton and commune level, which is basically applicable to all structures with an actual settlement function, such as the underground parts of residential, commercial, industrial, or public buildings. This also includes utility facilities such as water pipes, electricity cables, and wastewater pipes, as well as individual structures like car parks. There are no specific statutory regulations

regarding underground structures and facilities. Any general legal, professional, and other standards apply to them too (as regards air, see [13]).

Construction laws talk about building over plots, about the height of buildings, and their depth (which serves as a measure for a certain length of facade). Stories below ground do not count toward any maximum dimensions for usage purposes, which means underground structures and those parts of buildings located underground can free up more space for use. Underground parts of buildings must not extend beyond the confines of the parcel of land concerned for reasons associated with landed property law. But the depth of underground parts of buildings is unlimited in principle in terms of construction law as applicable to communes. As already outlined (see section 2.1 above), water protection law at federal level contains restrictions regarding depth in the interest of groundwater protection.

3.5 Procurement of Raw Materials

The procurement of raw materials comes under the so-called mining prerogative right. Prerogative rights are cantonal monopolies which predate the issue of the Federal Constitution in 1874. They allow the cantons to apply exceptions to the principle of economic freedom which would otherwise not be available to them in support of their activities (only the Confederation can conduct economic policy). Prerogative rights have their legal basis in the cantons' constitutions and may be enacted in a special law (Mining Prerogative Act, "Subsurface Act", and the like). The prerogatives involved mainly apply to the ground, such as mining and salt prerogatives. The monopoly gives the canton the exclusive right of use, which it can pass on to other parties, e.g., private individuals, by conferring rights (a license) (see section 3.3 above).

4. Coordinated Planning of Subsurface Use

4.1 Planning System

The system of spatial planning in Switzerland covers several instruments which make up a kind of hierarchy. There is a higher strategic and coordinating level in the form of the *structural plan*, which the cantons are responsible for issuing. With measures to reconcile matters across the cantons, this is intended to create a whole applicable to Switzerland in its entirety. Structural plans are binding on the authorities, particularly those who then define *land use plans*. This second level may be described as the regulatory level [8]. Land use plans are binding on all parties and determine possible uses in detail down to individual plots of land. The communes are generally responsible for issuing these and have to get the cantons to approve their land use plans. The third level covers (construction) *permits* issued for individual projects, as well as stipulations regarding land use planning and any applicable legal provisions that need to be complied with.

The subsurface is to be understood as an integral whole in which the various uses interact [8]. Just as in principle each structure or installation constitutes a system which not only comprises the object (building, road, pipe) but also has an impact on the environment (noise, vibrations, air pollution), each project needs to be understood in a broader sense. Within the subsurface, it is especially important to record objects and their mutual influences, because there are fewer restrictions on heights and it is much harder to get an overview of conditions compared with at the surface. Therefore it is important to prepare the required informations about the subsurface within the planning process (see the cautionary tale section 4.4 para. 1 below as well).

The following diagram represents the various types of use within the subsurface and they how influence and interfere with each other.

The need for comprehensive coordination is all too clear from the diagram. This demands that the relevant data and information concerning the subsurface be systematically recorded, that the possible uses the subsurface offers be determined, and that any future

uses be planned. The uncertainties which exist during these phases make a particularly compelling case for forward-looking spatial planning, which — thanks to its capacity to manage crossover issues — can deliver a supra-local and supra-disciplinary brand of holistic spatial planning based on the relevant risk conditions [14]. As such, spatial planning precedes any individual decisions and generates information (about, say, geology) that provides the basis for spatial planning. This applies to both models: both the one focusing on needs and the one focusing on the potential of the subsurface [15]. Coordination is the core task in terms of spatial planning and the one with the highest priority. This applies to conventional spatial planning, due to the specific local conditions, but particularly to spatial planning involving the subsurface.

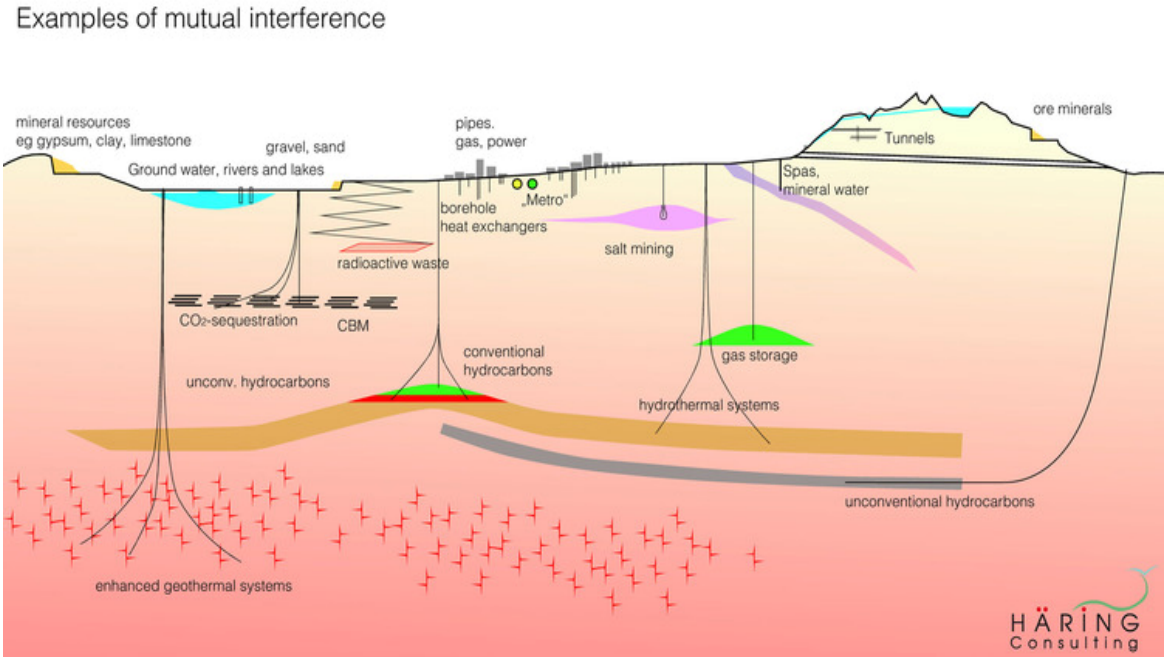

Fig. 4 Examples of mutual subsoil interference (Markus Häring, Häring Consulting, 2015).

4.2 Structural Planning

The instrument to be used across Switzerland for coordinated planning (reconciling the various activities with an impact on space, both existing ones and any still at the planning stage), which contains stipulations that are binding on the authorities, is the cantonal structural plan or structural planning. Structural planning is the ongoing process, while the structural plan is the relevant snapshot when plans are actually defined. “Binding on the authorities” means the authorities issuing the planning for the next level that is binding on everyone — land use planning (see section 4.1) — are bound by what is set out in the structural plan. All projects with a significant impact on space and the environment must have some kind of basis in the structural plan (art. 8 para. 2 of the RPG); this essentially means any projects that need to be coordinated with other projects. The structural plan consists of a map and text, both of which are equally binding. The map depicts the locations of activities, while the text details what has been set out in word form, rather than simply providing an explanation of the map.

There is no cantonal structural plan specifically concerned with the subsurface. Registration of groundwater stocks, as well as cantonal areas of interest for groundwater use, involves a coordinated approach. The structural plan may envisage some prioritization, besides showing the need for reconciliation [7]. The existing cantonal structural plans still say nothing about, say, drilling for

geothermal energy, even in those cantons which have already forged ahead with such work. The structural plan makes occasional reference to overviews showing areas in which, for example, geothermal heat probes are permitted (see the structural plan for the canton of Thurgau, section 4.2, p. 9, which is not yet, of course, a planning-related service). But the normative criteria in the structural plan may also apply, to all intents and purposes, to the planning of subsurface uses. It will be necessary, however, to contemplate three-dimensionality in terms of how things are represented. The peculiar thing about (structural) planning in relation to the subsurface is how reference to underground uses is made at the surface [9]. Because there is no such thing as purely underground planning, with all activities having some impact on the surface [7]. From a planning perspective, the talk would be more about the overall "underground dimension" of the city — as opposed to the "underground city".

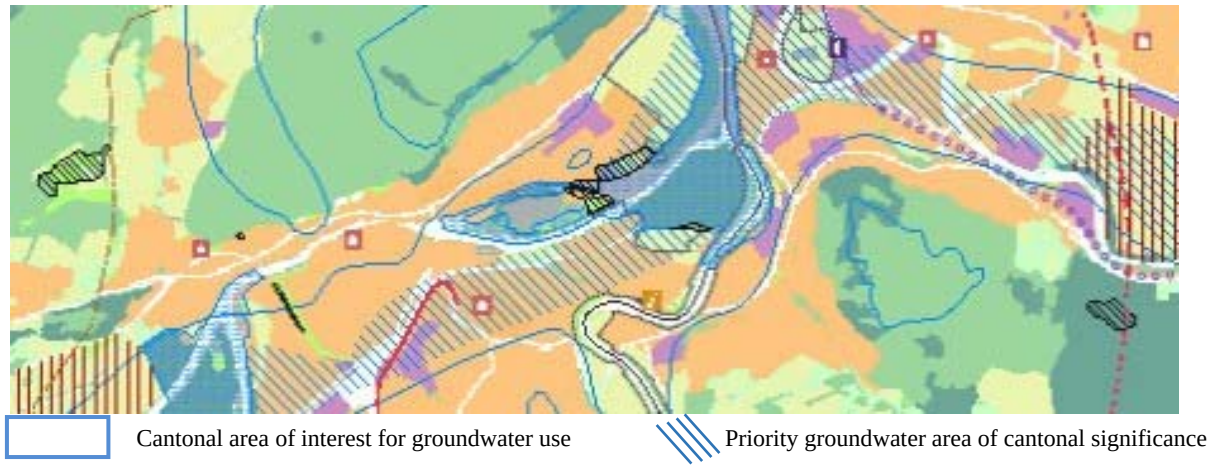

Fig. 5 Structural plan for the canton of Aargau (detail: Brugg – Windisch – Turgi).

4.3 Land Use Planning

Land use planning is the next level in the planning hierarchy. The specific possible uses are defined, in terms of sovereignty, in a land use plan — these days usually at commune level and by the legislator for the commune. The land use plan is binding on all parties, particularly the landowners and any other parties with rights and obligations in respect of the land and ground. Things are set out in terms of property (down to "individual plots" of land) within zones. There are land uses (e.g., three-floor residential zone, commercial zone associated with moderate disruption, industrial zone) and so-called overlying zones (e.g., water and groundwater protection zones, preservation orders, natural hazards). Whereas the structural plan only contains projects that require some coordination, the land use plan has to contain anything that needs to be defined regarding local arrangements for approved use of the ground. The land use plan is also drawn in two dimensions but needs to be understood in three; it restricts itself, however, to ground use and mainly how this takes effect above ground [7]. It would also have to be possible to issue the underground land use plan as a three-dimensional representation. As regards subsurface use, the land use plan, which would be used first and foremost for planning in relation to the shallow subsurface, would be able to give landowners some certainty [9].

4.4 Three-dimensional Modeling and Creation of Cadastres

In the old town of Staufen/Breisgau (Germany), the sinking of a number of geothermal heat probes in 2006 led to water ingress in dry sections of swelling rock. This resulted in so-called Gipskeuper swelling, whereby anhydrite swells in the presence of water to become gypsum and increases in volume by up to 60%.

This prompted the old town to rise (it is still rising), which causes considerable damage to buildings with significant financial implications [16] (see also the example for [17]). Such damaging situations should be tackled by finding out about the condition and physical properties of the subsurface. The tool for this is the geological 3D model, which was first created in Basel as a project-specific model for addressing issues limited to the locality, particularly relating to groundwater and earthquake protection, but is now being developed into a 3D layer model that can be used to evaluate various possible uses. In the meantime, the goal is to develop a dynamic 3D model as a tool for underground spatial planning [18].

The geometric documentation of landed property by means of official surveys (3D landed property) is now a task of equal importance to both use above ground and use of the subsurface. Then there are the documentation and administration of the space above and below the ground. From a technical perspective, it is possible to document and administer 3D problems in a legally compliant manner. The aim is to create a legally binding 3D cadastre [19, 20]. The 3D cadastre should be feasible in the near future — at least in urban centers [9]. There is also talk of a market for underground landed property [21].

The use of plots of land is subject to many public-law restrictions on land ownership (öffentlichrechtliche Eigentumsbeschränkungen or ÖREB), which are binding on landowners. These are based on what is decreed by legislative authorities (laws, ordinances, plans) or decisions by administrative authorities (plans, orders). There is still no central source of information for ÖREB. The ÖREB cadastre will close this gap by collating information from various areas (e.g., land use plans, project zones, building lines, groundwater and flood protection zones, noise sensitivity levels, height limits, safety zones) that are not included in the land register governed by civil law. The legal framework for the ÖREB cadastre is to be defined by the Confederation, with the cantons

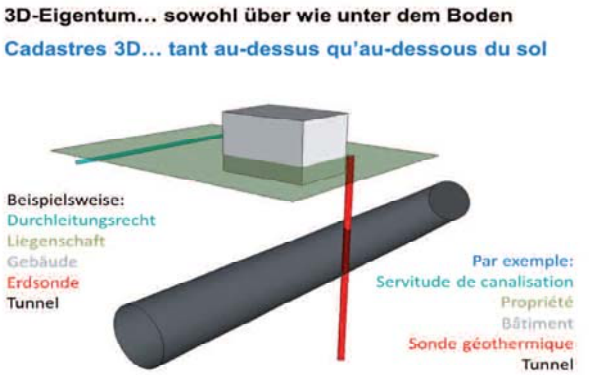

Fig. 6 3D-property, above- and underground (from: Åström Boss, 2014, p. 614).

organizing how the cadastre will be managed and determining the bodies responsible (Swiss Geoinformation Act of October 5, 2007, art. 16; see also the Ordinance on the Cadastre of Public-law Restrictions on Land ownership, ÖREBKV, of September 2, 2009).

5. Conclusion

Here are eight key points which could prove significant as regards planning for the underground dimension of the city [22, 23]:

- Taking account of the entire subsurface, regardless of depth (making no distinction between the shallow and deep subsurface);
- Taking account of all types of projects and uses, regardless of the scale;
- Comprehensive assessment of any impact on the environment;
- Creation of adequate legal foundations (in the RPG, in laws at canton level);
- Revitalizing spatial planning instruments, primarily in terms of structural planning and the structural plan, attempting to represent things in three dimensions. The land use plan should also be used to designate uses of the subsurface;
- Better “interlinking” of the approval processes to be developed on the basis of specific laws (e.g., laws on mining prerogatives and the Swiss Nuclear Energy Act, Railways Act, and Federal Act on Highways);

- Making coordination of projects a matter of "routine";
- Harmonization of provisions at both canton and commune level.

A group of experts concerned with "Use of the Subsurface" was set up in 2012. This was established as a private initiative and represents a loose grouping of natural persons with an interest in issues relating to use of the subsurface in Switzerland. Its mandate is to help improve coordination of how the subsurface is used by researching and developing concepts and strategies — particularly from a methodological, organizational, planning, legal, technical, political, and social perspective. The (voluntary) work involved is performed to academic standards. The group of experts is led by a three-person steering committee. The group runs two workshops a year and is involved in interdisciplinary projects. It also does work for government bodies and is currently, for example, involved in legislative projects at federal level.

Abbreviations

ARE Bundesamt für Raumentwicklung (Federal Office for Spatial Development)
BAFU Bundesamt für Umwelt (Federal Office for the Environment – FOEN)
BFS Bundesamt für Statistik (Federal Statistical Office)
BGE Entscheidung des Schweizerischen Bundesgerichts (Decision of the Swiss Federal Supreme Court)
BR Bundesrat (Federal Council – Government of Switzerland)
CHGEOL Schweizerischer Geologenverband (Swiss Association of Geologists)
E. Erwägung (deliberation – in the context of court rulings)
EGK Eidgenössische Geologische Fachkommission (Federal Geological Commission – FGC)
GEODH Geothermal district heating
IDHEAP Institut de hautes etudes en administration publique (Swiss Graduate School of Public Administration)
PFC Perfluorinated chemicals
PNR Programme national de recherche (National research program)
RPG Bundesgesetz über die Raumplanung (Federal Act of June 22, 1979, on Spatial Planning – with significant changes made on June 15, 2012)
SSV/IGGK Schweizerischer Städteverband/ Interessengemeinschaft Grosse Kernstädte (Swiss Cities Association/Interest Group for Major Core Cities)
URP/DEP Umweltrecht in der Praxis/Droit de l'environnement dans la pratique (Environmental Law in Practice – journal)
VOC Volatile organic compounds
ZBGR Schweizerische Zeitschrift für Beurkundungs- und Grundbuchrecht (Swiss Journal of Notarization and Land Registry Law – journal)
ZGB Schweizerisches Zivilgesetzbuch (Swiss Civil Code of December 10, 1907)

Legend to Illustrations

Underground Cargo:	
Umschlag	Transfer
Soil as a Store of Solar Heat?:	
D4 Unternehmens- und Innovationszentrum, Root	D4 Corporate and Innovation Center, Root (town)
PrinzipEnergiekonzept	Principle of energy concept
ÜbergabestationenHeizung/Kälte	Transmission station, heat/cold
Direktkühlung	Direct cooling
Geothermiespeicher	Geothermal energy store
49 Sonden je 160 m	49 probes every 160 m
Raumheizung	Heating for space
Raumkühlung	Cooling for space
Interne Fernleitungen	Internal pipelines
Eisspeiche	Ice store
Heizkessel	Boiler
Wärmepumpe/Kältemaschine	Heat pump/Refrigerator
Wärmespeiche	Heat store
BWW	Hot service water
Sonnenkollektoranlage 660 m^2	Solar collector system 660 m^2
EinpeisungSolarenergie	Solar energy infeed
3D landed property:	
3D-Eigentum… sowohl über wie unter dem Boden	3D landed property… both above and below ground
Beispielsweise:	For example:
Durchleitungsrecht	Transmission right
Liegenschaft	Property
Gebäude	Building
Erdsonde	Geothermal probe
Tunnel	Tunnel

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Modern Environmental Science and Engineering (ISSN 2333-2581)
September 2017, Volume 3, No. 9, pp. 614-624
Doi: 10.15341/mese(2333-2581)/09.03.2017/002
Academic Star Publishing Company, 2017
www.academicstar.us

Leachate for Producing 3rd Generation Microalgal Oils

Zareen T. Khanzada, and Süleyman Övez

Environmental Biotechnology Programme, Department of Environmental Engineering, Istanbul Technical University, Turkey

Abstract: The ability of microalgae to grow well under certain wastewater conditions has indicated the potential of these resources as environmentally sustainable growth medium for producing 3rd generation biodiesel feedstock. Ultra-membrane treated landfill leachate was used as a nutrient medium for growing native microalgal cultures to produce oil for future biodiesel energy conversion. A total of three lab scale experimental sets with different dilutions of leachate were tested with altering pH and phosphate addition. At the end of batch experiment, priliminary results showed highest microalgal dry biomass (2.5 g L^{-1}) in 50% leachate with minimum total cell lipid content. Microalgae grown in 10% leachate (~ 50 mg L^{-1} $N\text{-}NH_4^+$) produced maximum total cell lipid content (114.64 mg g^{-1} dry biomass). Phosphate addition in leachate enhanced the microalgal dry biomass production in higher leachate dilutions (10-50% TL) but total lipid content did not show any significant increase. Leachate stress can be screened further for inducing microalgal lipid production.

Key words: microalgal lipids, landfill leachate, biodiesel feed stock

1. Introduction

1.1 Microalgal Biomass — A Sustainable Alternative Feedstock for Biodiesel

The investigation on microalgae as a sustainable alternative energy source for transportation fuel is not new but the prevailing oil crisis in the oil producing regions, fast depleting fossil oil reserves and environmental pollution concerns (release of green house gases GHG etc.) have made it imperative for organizations and countries to invest more time and efforts into research on sustainable, renewable, environmental friendly-carbon neutral feedstock for biodiesel such as microalgae [1-6].

The renewed interest in microalgae for producing oils is due in part to the high lipid content of some species — 10-30% of dry weight. Lipids and fatty acids form a major part of a microalgal cell as membrane components, metabolites and storage products [7]. Microalgae contain storage lipids (triglycerides TAG) suitable for transesterification for biodiesel conversion [2, 8]. In fact paleobotanical evidence has also suggested that microalgae are responsible for major sources of hydrocarbon (fossil fuels) in a variety of oil-rich deposits dating from the Ordovician period to the present [1, 9, 10].

Eukaryotic algae contain a diverse composition of acyl lipids and their fatty acids. Even within divisions, individual algae contain a bewildering array of lipid compositions (such as saturated fatty acids, polyunsaturated fatty acids, glycolipids or triacylglycerols). Their lipid content differ from strain to strain and can also be adjusted through altering nutrient (C, N, P ratios) and growth conditions (temp, light intensity or pH etc.) [2, 11-13].

1.2 Utilizing Wastewater Resources for Growing Microalgae

The statement made by Chisti [14] in his research article that microalgae produce 15-300 times more oil for biodiesel production than traditional crops on an area basis, further intensified the interest in research

Corresponding author: Zareen T. Khanzada, Ph.D., research areas/interests: environmental sustainability, biological tertiary wastewater treatment. E-mail: xaripink@yahoo.com.

and development of 3rd generation microalgal biofuels [1, 3, 4, 6]. Some researchers suggested that the claim made by Chisti [14] was not realistic with the then present technology and available strains, and the only way for microalgae to compete with terrestrial crops in the race of 2nd generation biofuels was to use wastewater [2,15,16].

Microalgae are known to grow more abundantly in nutrient rich (high N and P) eutrophic waters leading frequently to algal blooms [1]. If this nutrient requirement for large scale microalgal cultivation is provided by chemical fertilizers then it will provide an immense upstream burden to the life cycle analysis LCA of microalgae biodiesel production system [17-19]. The processing stages of microalgae biofuels need to be simplified with virtually zero energy input for long-term sustainability and environmental benefits [20]. Zhou et al. [21] evaluated that using waste organic biosolids from only three major sources (municipal wastewater, livestock manure and food waste) could potentially support enough bio-crude oil production to completely replace the US demand for petroleum imports.

Dual-use microalgae cultivation for wastewater treatment coupled with biofuel generation has been an attractive option in terms of reducing the energy cost, GHG emissions, and the nutrient (fertiliser) and freshwater resource costs of biofuel generation from microalgal large scale cultivation [6, 11, 22].

1.3 Sanitary Landfill Leachate

A sanitary landfill is a biological reactor to treat and allow final disposal of municipal solid wastes around the world. Leachate is a strongly contaminated liquid that accumulates beneath the landfill site as a result of natural infiltration processes, bio-chemical reactions from both natural degradation as well as compression of the waste and rain water. Landfill leachates LFL often consist of increasing concentrations of toxic xenobiotic organic compounds, Ammoniacal nitrogen ($N\text{-}NH_4^+$), salinity (chloride ions Cl^-) and heavy metals etc. [23-25].

The major potential environmental impact of LFL is pollution of soil, surface water and groundwater. The toxics in LFL can over load the ecosystem, disrupting the natural recycling processes such as photosynthesis, respiration, nitrogen fixation, precipitation and evaporation [11]. To use leachate as a source of fertilizer and water for microalgal oil production, bring an added value which otherwise would be considered as waste needing treatment.

1.4 Leachate to Produce Microalgal Biomass-to-Bioenergy Generation

Since landfills continue to produce leachates throughout its lifespan even after closure, it could be used as a continuous nutrient source for large scale microalgal biomass production for biodiesel generation [26]. Depending on constantly varying characteristics of leachate, researchers around the world have investigated leachate in particular as a growth medium for microalgae for the treatment of toxic heavy metals, ammonia and organics etc. [25-30]. But literature on leachate treatment coupled with microalgal lipid production is scarce [31]. The objective of the present study was to evaluate the potential of ultra-membrane treated landfill leachate TL, taken from Istanbul municipal landfill (Odayeri Istaç-Istanbul Buyuk Şehir Belediyesi) to sustainably grow native microalgal cultures and to screen lipids in microalgal cells for supplying raw material for future biodiesel conversion.

2. Material and Methods

2.1 Culture Conditions

Mixed culture of fresh water microalgal species of Chlorella v*ulgaris* and Chlamydomonas *reinhardii* were obtained from Bioenergy department, Ege University. Ultra-membrane treated leachate TL was kindly provided by Odayeri management and stored at 4°C in 20 L air tight plastic containers in dark until use. Physico-chemical characteristics of autoclaved TL is presented in (Table 1).

Table 1 Characteristics of ultra-membrane treated leachate TL.

Parameter	(mg L^{-1})
Total organic carbon TOC	135.6
Ammonium NH_4	485
Ortho-phosphate PO4	5
Total dissolved solids TDS	18.74
Conductivity mS/cm	26.7
Salinity ppt	23.9
Chloride ion Cl^{-1}	9060
pH	7.5

Exponentially growing inoculum at a volumetric ratio of 20% (v/v) measured at an absorbance of 680 nm (using spectrophotometer, model U-2001, HITACHI, Japan) was used to start and monitor growth in the 3 experimental sets. BG11 UTEX medium used in the experiments consisted of the following nutrients: $NaNO_3$, $MgSO_4$, KCl, $CaCl_2$. $2H_2O$, $NaHCO_3$, $NaNO_3$, KH_2PO_4, K_2HPO_4, Fe Ammonium citrate, Citric acid, and trace elemental solution. Trace elemental solution includes $CuSO_4$. $5H_2O$, $ZnSO_4$. $7H_2O$, $MnCl_2$. $4H_2O$, $CoCl_2$. $6H_2O$, $FeSO_4$. $7H_2O$, EDTA, H_3BO_3, $NaMO_4$. $2H_2O$.

Cultures were put in 1L glass bottles with 500 ml working volume, continuous air bubbling was supplied at a rate of 3 L/min (flow rate in each bottle was around 0.31 ml min^{-1}), continuous artificial irradience of 60 µmol $m^{-2}s^{-1}$ was provided through white fluorescent lamps (measured by a digital light meter - linkoln USA) and maintained at room temperature of 25±1°C. Cultivation was carried out under batch mode in dublicate for 27 days. The data was statistically analyzed by Student's t test comparing the control at $p \leq 0.05$. Values presented in the results section are averages of dublicate cultures.

2.2 Lab Experimental Setup

A set of 3 experiments were conducted with same cultivation conditions as mentioned in section 2.1. Different dilutions of autoclaved (20 min at 1 atm, 121°C) treated leachate TL (i.e., 10%, 30%, 50%, 70%, 90%, 100%) with distilled water (dw) as –ive control and regular BG11 media as +ive control, were formulated to evaluate microalgal growth and lipid content. 0.5 N $NaOH/H_2SO_4$ was added manually on alternate days for pH control. The only difference in the experiments was as follows:

- In experimental set 1, pH was maintained within a range of 6.5-8.5.
- In experimental set 2, pH was maintained within a range of 6.5-7.5 and
- In experimental set 3, pH was maintained at a range of 6.5-7.5 with phosphate addition (same as BG11 media with N/P ratio 40:1).

2.3 Microalgal Biomass Dry Weight and Lipid Extraction and Staining

Biomass dry weight was measured by filtering the microalgal samples through whatman filter papers (0.7 pore size, GF/F) at the start and end of each batch cultures. Filters were oven dried at 60°C until constant weight (~ 3 days) and then weighted on a measuring balance.

Dried algal biomass was homogenized in mortar and pestle and 500 mg from each experimental set was subjected to lipid extraction following folch method [32] with sonication. 10 ml mixture of chloroform and methanol (2:1) was added to dried biomass in a glass tube and undergone sonication (50 Hz) for 20 min. The extract was equilibrated with 1/4th its volume of a saline solution and vortexed. The tubes were centrifuged at 2000g for 10 min for the separation of two layers. Lower chloroform layer containing lipids was carefully transferred to pre-weighted glass vials and dried under fume hood at 80°C. The dried lipids were then gravimetrically measured.

Nile red (9-diethylamino-5H-benzo [α] phenoxazine-5-one, $C_{20}H_{18}N_2O_2$) staining of microalgal intact cells containing neutral lipids was carried out using fluorescence microscopy (OLYMPUS BX50 with attached camera) [33]. Oven dried microalgal biomass was homogenized in pestal and mortar. Wasted with phosphate buffer and

centrifuged twice and then 10 µm was spread on glass slide with 10 µm nile red stain and 30% ethanol solution. Slides were visualized under florescence microscopy.

3. Results and Discussion

3.1 Microalgal Biomass Growth in the 3 Experimental Sets

Microalgae usually accumulate lipids as part of their grown up cells, that's why growth curve was first carefully monitored to check if TL was supporting microagal biomass growth. The high nitrogen content of TL makes it attractive for microalgae cultivation as green algae demand more nitrogen and phosphorus than do many other plant species but the same nitrogen source $N\text{-}NH_4^+$ can become toxic in higher concentrations. Excessive $N\text{-}NH_4^+$ can damage photosynthesis organs (chloroplast) and decrease photochemical efficiency [34].

In the present study both stimulatory and inhibitory effects of TL was observed on miroalgal growth in the 3 experimental sets. Irrespective of an adaptation time (~month) given to microalgae before the start of experiments, cultures still showed a lag phase of around 3-5 days in all the formulations (10%-100% TL) due primarily to high total dissolved solids (susceptable for fresh water species) and inconsistency of nutrient compositions in leachate or inhibition by some possible hidden element in leachate medium (Figs. 1-3; Table 1). In experimental sets 1 and 2 microalgal growth in all the dilutions (10%-100% TL) was significantly lower than regular nutrient media BG11 as shown by growth curves (Figs. 1, 2). Experimental sets 1 and 2 were only different in pH ranges, which was established to check its effect on biomass growth. pH above 8.5 can start formation of free ammonia gas, which can leave the liquid medium and could no longer be available for microalgae to assimilate as a nitrogen source for its growth. But the growth curves did not show any significant effect of varying pH ranges on the growth curves of microalgae, which could imply that nitrogen was not lost from the medium in experimental set 2 in the form of ammonia gas (Figs. 1, 2).

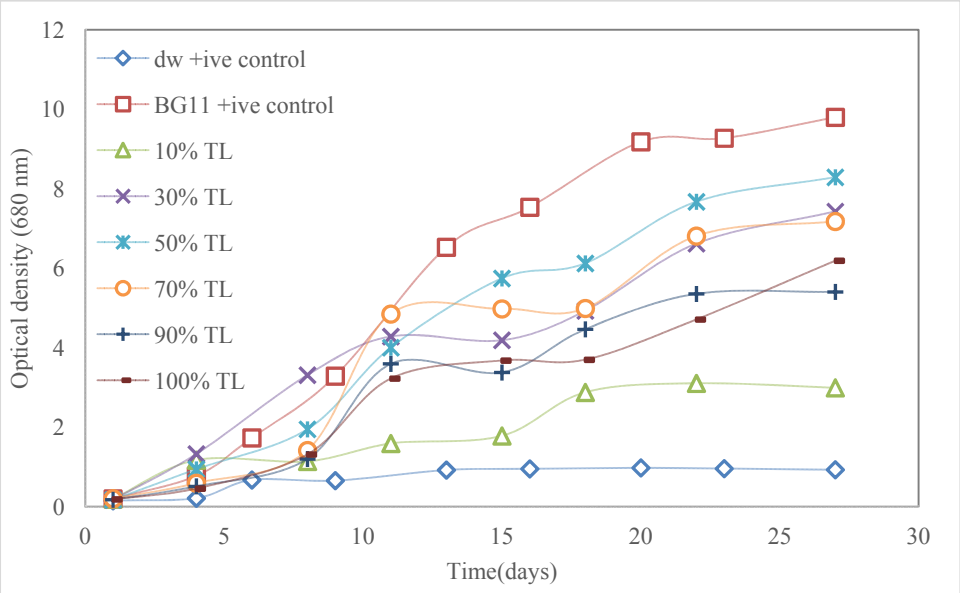


Fig. 1 Experimental set 1 — Biomass growth curve of microalgae in different dilutions of TL.

In general all the dilutions supported microalgal growth in a bell shaped curve, with 50% TL supporting the highest biomass growth in all the 3 experimental sets and the rest of dilutions showing decrease in successive order (Fig. 4). In 10% TL, nutrients seemed insufficient due to dilution and the growth curve stayed

closer to negative control (dw) and very low dry biomass was observed (Figs. 1, 2, 4). In higher formulations (70%-100% TL) growth was slow and steady in all the 3 experimental sets, with growth curves not showing onset of proper stationary phase, but after day 20th there was an upward increase in growth curve albeit at a very slow pace.

TL had sufficient nitrogen source in the form of $N\text{-}NH_4^+$ to support microalgal growth but was limited in phosphorus P, which is an essential nutrient for growth [35-37]. Experimental set 3 was supplemented with phosphate $P\text{-}PO_4^-$. Since at pH 8 or more phosphate can precipitate [38], in experimental set 3, pH was kept within 6.5-7.5 range to make sure any phosphate elimination from the medium was from metabolic uptake by microalgae. All the TL dilutions after $P\text{-}PO_4^-$ addition showed better growth curves and dry biomass than previous experimental sets 1 and 2 (Figs. 3, 4). After $P\text{-}PO_4^-$ addition, 50% TL showed the highest microalgal growth almost equal to BG11 media with 2.50 g L^{-1} dry biomass (Figs. 3, 4, 6b).

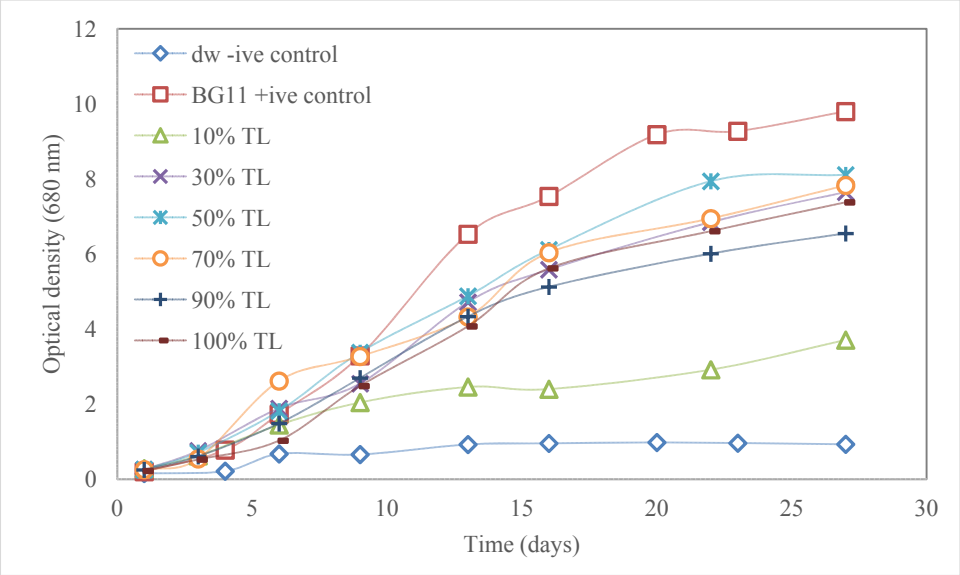


Fig. 2 Experimental set 2 — Biomass growth curve of microalgae in different dilutions of TL.

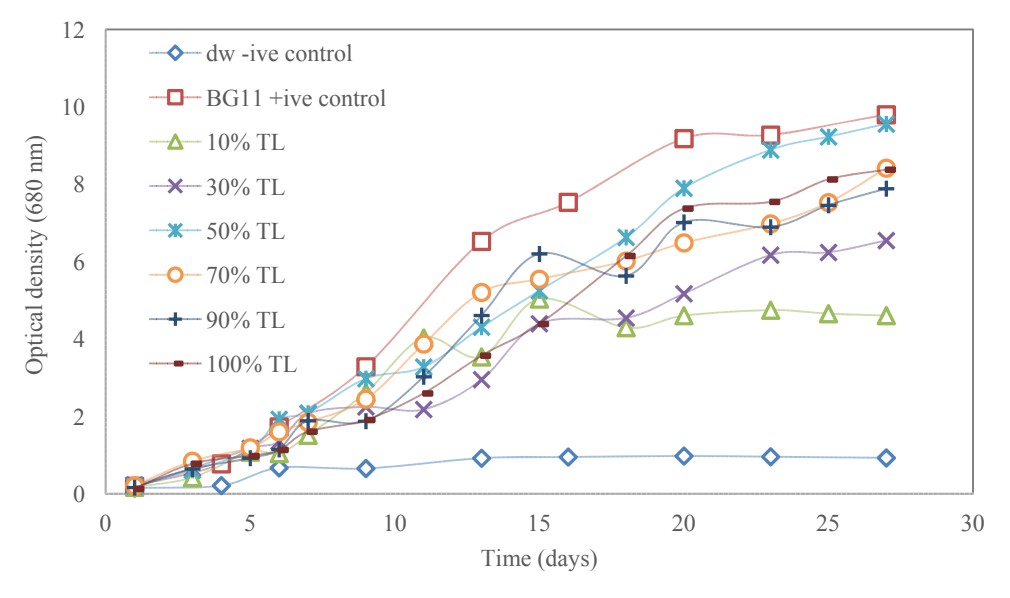


Fig. 3 Experimental set 3 — Biomass growth curve of microalgae in different dilutions of TL.

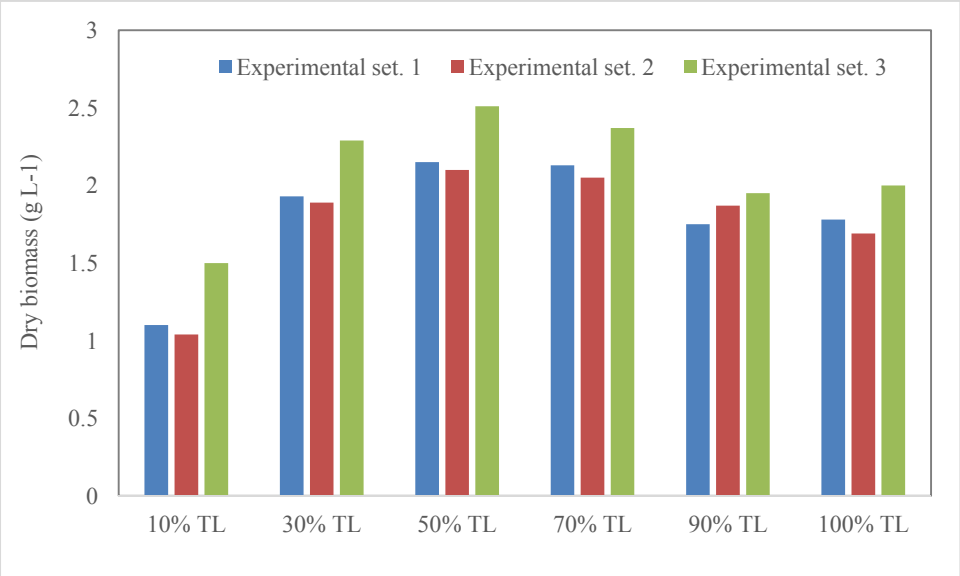


Fig. 4 Microalgal dry biomass (g L^{-1}) in different dilutions of TL in the 3 experimental sets.

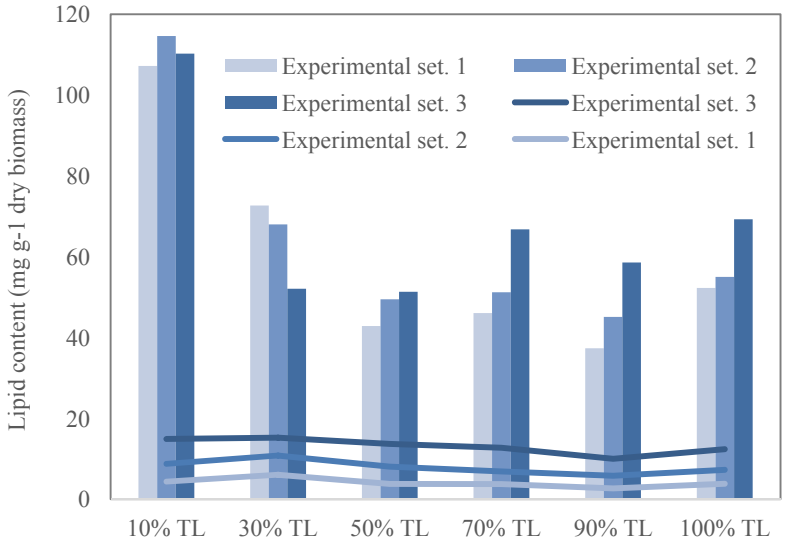


Fig. 5 Microalgal total cell lipid content (bar graph) and lipid productivity (stacked line) in different dilutions of TL for the 3 experimental sets.

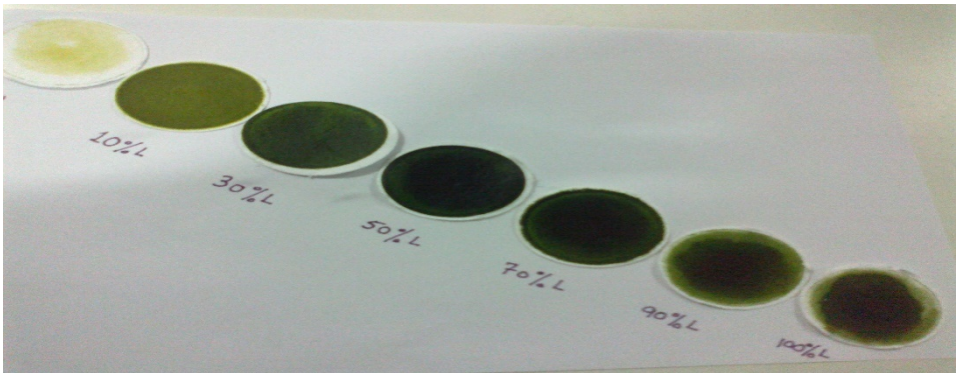
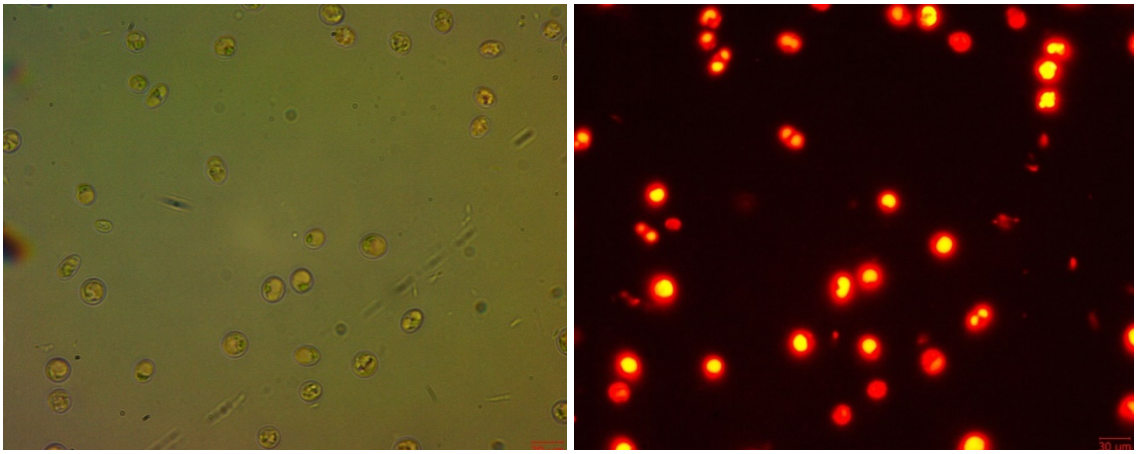


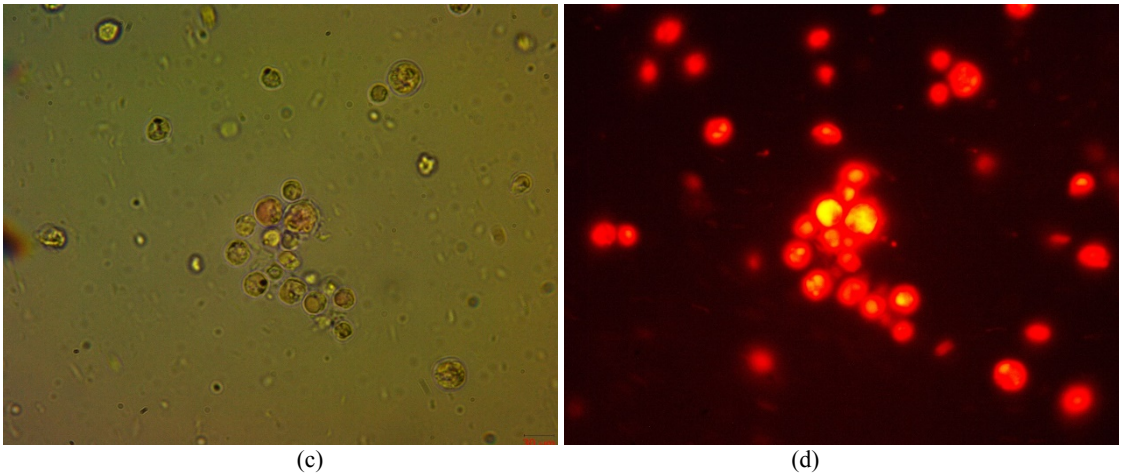
Fig. 6a Oven dried filtered dry weights of microalgal cells grown in different dilutions of TL.

Fig. 6b Cultures in different dilutions of TL at the end of batch cultures.



(a) (b)

Fig. 7 Nile red staining of dried microalgal cells grown in 10% TL: (a) Dried cells under 100x magnification using normal microscope; (b) Same cells with their stored lipids (yellow region) stained with nile red as observed under florescence microscope (green excitation filter at 604 nm).



(c) (d)

Fig. 7 Nile red staining of dried microalgal cells grown in 50% TL: (c) Dried cells under 100x magnification using normal microscope; (d) Same cells with their stored lipids (yellow region) stained with nile red as observed under florescence microscope (green excitation filter at 604 nm).

3.2 Microalgal Lipid Content in the 3 Experimental Sets

In any process aimed at oil production by photosynthesis, the key objective is a high photosynthetic efficiency of lipid production. According to literature survey environmental stress conditions particularly decreased nitrogen in the medium, induces oil production in microalgal cells. Rodolfi et al. [2] evaluated that when nitrogen deprivation is imposed upon a culture exposed to suitable irradiences, photosynthesis continues, albeit at a slow rate and the fixed carbon flow is diverted from protein to either lipid or carbohydrate synthesis. The major limitation of this approach is that despite the fraction of lipids may increase, biomass productivity of the microalgal cells is often very low and so overall lipid productivity will not be high. Growth conditions that focus on providing high biomass productivity instead may ultimately be more economical and may be a more efficient means of increasing total lipid productivity [2, 11, 39]. Similar trend was observed in the present study where 10% TL (~ 50 mg L^{-1} $N\text{-}NH_4^+$) had the lowest biomas yield, but it produced highest lipid content (107.24-114.64 mg g^{-1} dry biomass) (Fig. 4, 5). 50% TL (~ 248 mg L^{-1} $N\text{-}NH_4^+$) showed highest microalgal growth interms of dry biomass in all the 3 experimental sets but lipid content was almost half when compared with 10% TL (Figs. 5, 7bd). Microalgae growing in 50% TL and 100% TL produced almost same lipid content, which implied that TL can be used without dilution in further studies to optimize lipid yield.

3.3 Effect of Phosphate on Lipid Content

To enhance oil yield of algae cultures the cell lipid content should be increased over the basal value without significant losses of productivity. The high biomass productivities (in some cases high lipid productivities) of the wastewater-grown microalgae suggests that there is real potential in the utilisation of these high nutrient resources for cost-effective biofuel generation and production of sustainable and renewable energy [39]. Although culture composition and growth conditions may be less managable in municiple wastewater and most microalgae have relatively low total lipid content per cell under wastewater conditions, ranging from low (< 10% dry biomass) to moderate (25-30% dry biomass) lipid content, the high biomass productivity potentially can translate to significant total lipid productivity [6, 11].

In the present study Phosphate $P\text{-}PO_4^-$ was added in experimental set 3 to enhance the growth of microalgae which was hypothesized to further increase the cells lipid content and productivity. Phosphate $P\text{-}PO_4^-$ addition significantly enhanced the biomass growth curves and dry biomass of microalgae in higher dilutions (10%-50% TL) but the lipid content did not show any significant difference when compared with experimental sets 1 and 2 (Figs. 3-5). Phosphate addition increased lipid content and productivity in lower dilutions (70%-100% TL) (Figs. 5, 6a). Chu et al. [40] pointed out that phosphorus plays a significant role in lipid production under nitrogen deficiency. In their study excess phosphate (35 mgL^{-1}) in nitrogen starvation conditions achieved highest lipid productivity (58.39 $mgL^{-1}day^{-1}$) but lipid content remained the same after 14 days of cultivation. While in the present study, it seemed that phosphate $P\text{-}PO_4^-$ was mainly metabolically uptaken for growth purposes and was not sufficient enough to induce lipids production in microalgal cells in higher dilutions (10%-50% TL) but in lower dilutions (70%-100% TL) $P\text{-}PO_4^-$ induced lipid production with no enhanced growth (Figs. 4, 5).

Study by Xin et al. [36] suggested high lipid content (53%) and productivity (0.075 gL^{-1}) under phosphorus limitation. However under nitrogen limitation lipid content was enhanced (30%) but productivity per unit volume of the culture medium was rather low because the algal biomass was also very low (0.05 g L^{-1}). In the present study, cultures in

10% TL produced the highest lipid content irrrespective of phosphate limitation (sets 1 and 2) or addition (set 3) (Fig. 5). The cultures in 10% TL turned pale green after around 10 days and remained so until the end of each batch cultures (Fig. 6b).

Nile red staining of the pale green cultures of 10% TL further confirmed the increased lipid content when compared with 50% TL cultures (Figs. 6a, b; 7a, b, c, d). Almost all cells surviving in 10% TL had lipid storage in them, which absorbed nile red staining and readily responded to florescence microscopy. Since phosphorus addition and limitation had no significant effect on lipid content for higher dilutions (10-50% TL) in the 3 experimental sets, the only reason for increased lipid content in 10% TL can be attributed to nitrogen limitation (Figs. 4, 5). Under N-limited conditions microalgal cells degrade the intracellular abundant proteins to recycle amino acids into proteins more suited for survival. Another quick nitrogen source utilized under stress conditions is chlorophyll and any changes in chlorophyll content are directly reflected in the nitrogen content of microalgal biomass [41]. In the present study the pale green cultures in 10% TL can be attributed to intracellular degradation of chlorophyll for survival of stressed microalgal cells.

In the present study dry biomass and lipid productivity was opposite to what Zhao et al. [31] had observed in their study. They grew Chlorella *pyrenoidosa* in a mixture of leachate and municipal wastewater with no external phosphate addition and their evaluated microalgal biomass was 1.58 g L^{-1} and lipid production was 24.1 mg L^{-1} d^{-1} in 12 days. While in the present study lipid productivity in 10% TL (with highest total lipid content per cell) was very low (~ 4.42 mg L^{-1} day^{-1}) but dry biomass was higher 2.5 gL^{-1} (50% TL). The lipid productivity observed in the present study was in the lowest range according to literature [15, 20]. Leachate is a complex mixture of constantly varying compounds and it might have some possible inhibition or toxic effect on lipid production. Also the possible positive impact of waste addition (stressed condition) on lipid induction may sometimes not proceed as expected. As observed by Kim et al. [42] where microalgal growth following the addition of fermented swine urine was increased by nearly 3-fold (197 mg L^{-1} dry biomass in treated cells over 76.5 mg L^{-1} in control cells) over a 31 day growth period, but the total fatty acid content was significantly reduced (9 mg g^{-1} dry biomass in treated cells compared to 46 mg g^{-1} in control cells).

4. Conclusion

Optimized biomass production is central to economic biodiesel production and this in turn requires careful optimzation of microalgal cultivation systems. In the present study priliminary results suggested that irrespective of high N-NH_4^+ and other stresses in leachate media, fresh water microalgae were able to grow biomass in all the experimental sets and produced lipids. Altering pH of the medium had no significant effect on biomass and lipid content in the 3 experimental sets but addition of phosphate significantly increased the biomass in higher dilutions (10-50% TL) and lipid content in lower dilutions (70-100% TL) of microalgal cultures. Total lipid content of dry biomass was in the lowest range and further screening is required to optimize the microalgae-to-bioenergy system using leachate to produce more lipid for future biodiesel production.

Acknowledgements

Authors are thankful to Istanbul municipal landfill management (Odayeri Istaç-Istanbul Buyuk Şehir Belediyesi) for providing them leachate and all the necessary facility. This study was funded by Santez (1643. STZ.2012-2) and BAP project (37972).

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Modern Environmental Science and Engineering (ISSN 2333-2581)
September 2017, Volume 3, No. 9, pp. 625-631
Doi: 10.15341/mese(2333-2581)/09.03.2017/003
Academic Star Publishing Company, 2017
www.academicstar.us

The Perception of Green Building Index Facilitator towards the Traditional Malay House Sustainability

Wan Mohd Fakhzan Wan Zakaria[1], Mawar Ahmad[2], and Mohd Zulkarnain Salehudin[2]

1. Alfa International College, Malaysia

2. Politeknik Sultan Haji Ahmad Shah, Malaysia

Abstract: Malaysia initiated the Green Building Index (GBI) evaluation tools to assess sustainability in construction industry. However, this evaluation only considers new construction for residential and non-residential regardless heritage buildings, particularly the Traditional Malay House (TMH). Therefore, this research was conducted to study the relationship of TMH sustainability components with GBI criteria. The aim of the discussions in this study is to investigate the perception of Green Building Index Facilitator (GBIF) towards TMH sustainability and to establish TMH sustainability assessment tool with reference to GBI criteria. In-depth literature was conducted to identify the key sustainability components of TMH. The data for this study was gathered through an online survey. Thus, self-administered questionnaires were employed as the primary data collection method. The questionnaires are distributed among GBIF which comprises of the architect, engineer, quantity surveyor and others. 31 samples were obtained in this study. From the finding, it can be concluded that the problem statement outline in this study, which suggest that the TMH also comply with recent GBI criteria were proven.

Key words: traditional Malay house, green building index, green building index facilitator

1. Introduction

Sustainability has been a major issue nowadays in this 21st century. Many developing countries try to promote this approach regarding the adverse effect of development and activities done by human being throughout many years on earth. Fortunately in Malaysia, this concept of sustainability had been already applied long time ago in the design of Malaysian vernacular house which designed and constructed with a deep understanding and respect for nature and it surroundings. The vernacular house of Malays known as Traditional Malay house evolved along different lines in the various regions and states of Malaysia. Traditional Malay House is designed and constructed with magnificent adaptation to Malaysia's natural surroundings and hot tropical climate. The traditional Malay house is influenced by various factors such as climate, culture, the owner's economic status, the surroundings, available building materials and religion of the Malays. These houses are well adapted to the hot tropical climate in which they are found and provide an excellent example of appropriate technology of that time to attune with the natural environment where it's settled [1].

Corresponding author: Wan Mohd Fakhzan Wan Zakaria, Msc., Lecturer; research areas/interests: heritage and conservation management. E-mail: wmfakhzan@gmail.com.

2. Literature Review

2.1 Green Building Index

In Malaysia there is an increasing public awareness and interest in how buildings affect the environment, worker productivity and public health. As a result, both the public and private sectors are beginning to demand buildings that optimize energy use, promote resource efficiency and improve indoor environmental quality. Developers, owners, operators, insurers, and the public as a whole are beginning to value and market the

benefits of sustainable building. Malaysia's commitment towards sustainable development was announced by the former Prime Minister of Malaysia; Tun Dr. Mahathir Mohamad, from his speech "The Way Forward" in 1991. His speech excerpts; "we must also ensure that our valuable resources are not wasted. Our land must remain productive and fertile, our water unpolluted, our forest resources capable of regeneration and able to yield the needs of our national development. The beauty of our land should not be desecrated; for its own sake and for our own economic advancement". Later on, those words translated as an immense national policy toward creating sustainable nation in 2020.

Green building rating tool enhances the environmental awareness of building practices and provides fundamental direction for the building industry to move towards environmental protection and the achievement of sustainability [2]. Green building rating tool was developed to measure the improvement of the building environment quality related to basic needs. Green rating tools by its nature and role is thus very dependent upon location and environment and thus climate. GBI Malaysia should be like-wise customized to suit both to our climate and also the current state of our country's development and existing resources [3]. The green building concept in Malaysia is built on five main components which are the building plan and materials, site management, water conservation, energy efficiency and healthy living [4].

Green building is designed to produce healthier and more productive work as well as living and learning environment. These will be accomplished through the use of more natural light and improved indoor environmental quality. From the financial perspective, green buildings are also cost effective and facilitate the owner to increase their profit by reducing the costs of operations and maintenance [5]. Thus, with this GBI rating system, there will be more initiatives by the key player of built environment industry to build green building design towards sustainable development in Malaysia.

2.2 Traditional Malay House

The TMH can say to be designed ecologically to balance with the local climate as what we call it today as sustainable designed [6]. Ahmad [7] also came out with the same agreement where he stated that traditional architecture cleverly appreciate climate which in turn become part of the cultural understanding in creating built form. According to Nasir & Teh [8], the TMH has satisfied the basic needs of the Malays adjusted to suit to the warm and humid climate. The architecture of TMH is so unique, "It created near-perfect solutions to the control of climate, multi-functional use of space, flexibility in design and a sophisticated prefabricated system which can extend the house with the growing needs of the family" [9].

3. Data Analysis and Finding

From the findings it shows that the relationship between the professions with the statement of TMH is a sophisticated prefabricated building and initiates the use of rainwater harvesting to infer that there was a tendency for most of the respondents to consider not sure or disagree for that sustainability statement of TMH.

Factors such as energy and water efficiency, indoor air quality, sustainable site planning and etc. are accounted as criteria. Even TMH is not designed using modern method and knowledge; it has already manifested the sustainability in many aspects. According to Talib & Sulieman [10], the traditional way of TMH designed is to produce a sensitive structure that in-tune with the environment where the green impact play an important role. In addition, Talib & Sulieman also stated that the TMH is designed ecologically to balance with the local climate as what we call it today as sustainable designed. Thus, those statements of TMH sustainability became acquiescent for most of the respondents.

The relationship between TMH sustainability components with GBI criteria were next to be analyzed. Twenty-two components were identified to discover the relationship of TMH sustainability components with reference to GBI criteria based on respondents' experience in GBI assessment project. From the analysis, results which imply the relationship of TMH sustainability components with GBI criteria are derived.

Based on the survey, most of the respondents are familiar or involved in GBI assessment project. From the survey, more than half of the respondents (based on percentage) either who are involved or not involved in GBI assessment project suggest that every identified TMH sustainability components have a significance relationship with the GBI assessment criteria. Indoor environmental quality (EQ) becomes the most commonly selected criteria at 8 out of 22 components. It is followed by the energy efficiency (EE) and sustainable site planning and management (SM) by 4 components per criteria, 3 components for material and resources (MR), 2 components for innovation (IN) and 1 component for water efficiency (WE). None of the components was selected as not applicable (NA).

These findings are also agreed by other scholars. They stated that EQ, EE, SM and MR are the most important elements in TMH. The Malay house is a model building that is environmentally sustainable. The house is essentially a timber post and beam construction that is lightweight and utilizes one of the earliest prefabrication methods in building construction [11]. Thus, the overall construction process of the TMH reflects a clear manifestation in the way of life and understanding of the Malays themselves in relation to man and the natural environment.

Fig. 1 (cut out ornamentations embedded at TMH allowed for natural ventilation), Fig. 2 (high and double-tier roof create volumetric space and stack effect), Fig. 3 (culturally prefer dimmed lighting indoors for privacy purpose), Fig. 4 (raised floor on stilts ensures good cross ventilation through the openings), Fig. 5 (gap between wooden flooring permit under-floor ventilation), Fig. 6 (the elongated and open concept plan design ease cross ventilation), Fig. 7 (fully openable window at body height provide thermal comfort) and Fig. 8 (semi enclosed *serambi gantung* and *selang* improve the indoor environmental comfort) have more than 50% preference for EQ from the total of respondents.

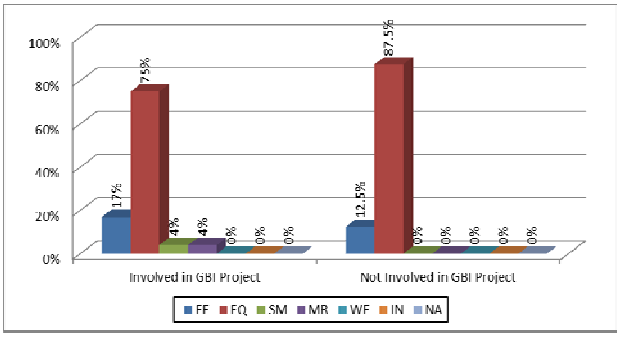

Fig. 1 Cut out ornamentations embedded at TMH allowed for natural ventilation.

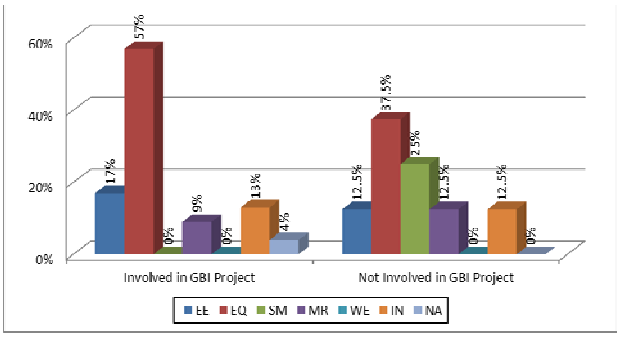

Fig. 2 High and double-tier roof create volumetric space and stack effect.

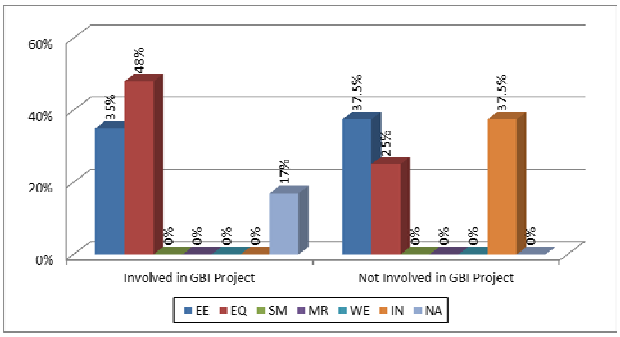

Fig. 3 Culturally prefer dimmed lighting indoors for privacy purpose.

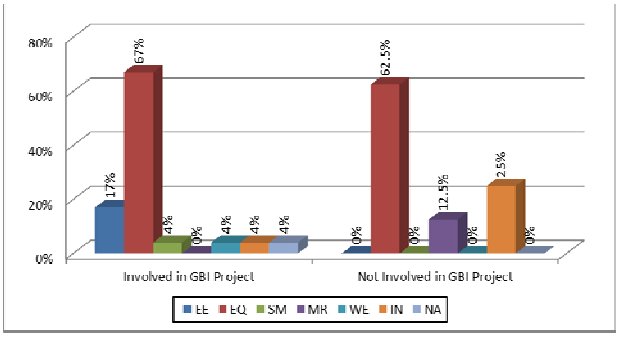

Fig. 4 Raised floor on stilts ensures good cross ventilation through the openings.

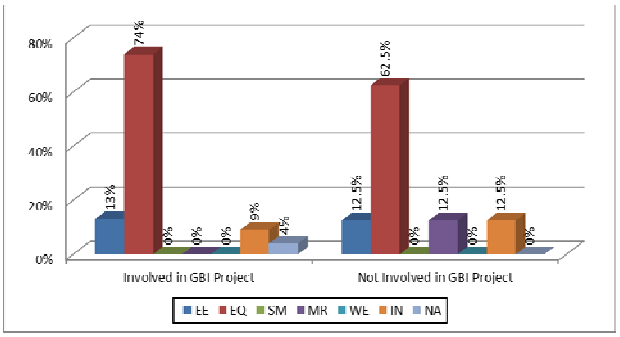

Fig. 5 Gap between wooden flooring permit under-floor ventilation.

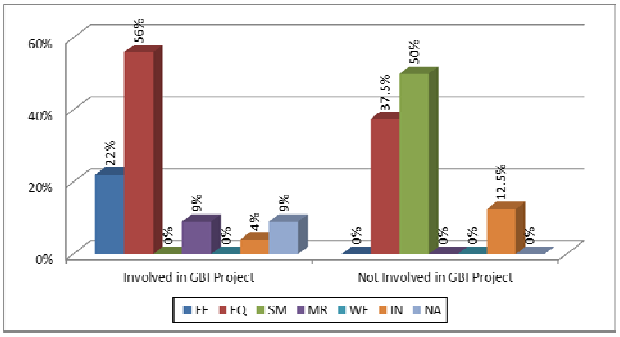

Fig. 6 The elongated and open concept plan design ease cross ventilation.

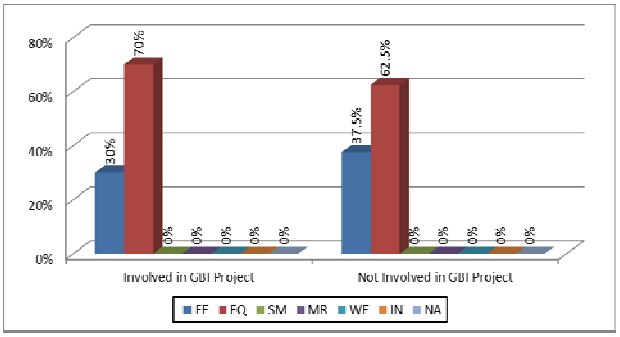

Fig. 7 Fully opendable window at body height provide thermal comfort.

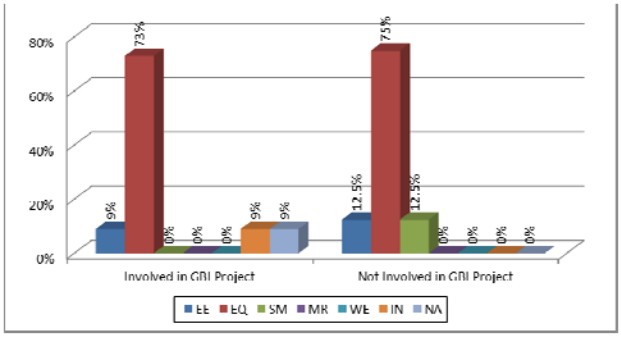

Fig. 8 Semi enclosed *serambi gantung* and *selang* improve the indoor environmental comfort.

However, for Figs. 2, 3 and 6 show that there are minor inclinations from respondents who are not involved in any GBI assessment project. This is resulted from the respondent's different point of views towards TMH sustainability components.

Meanwhile, EE criteria has been mostly selected by both group of respondents for Fig. 9 (cut out ornamentations embedded at TMH allowed for natural lighting), Fig. 10 (high and double-tier roof using materials with good thermal properties) and Fig. 11 (large roof overhangs and low wall height reducing the vertical areas of the house exposed to solar radiation).

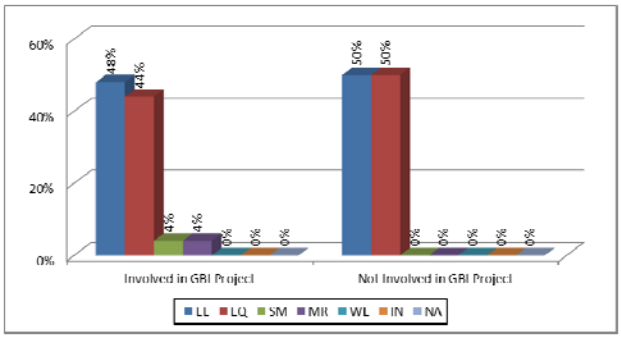

Fig. 9 Cut out ornamentations embedded at TMH allowed for natural lighting.

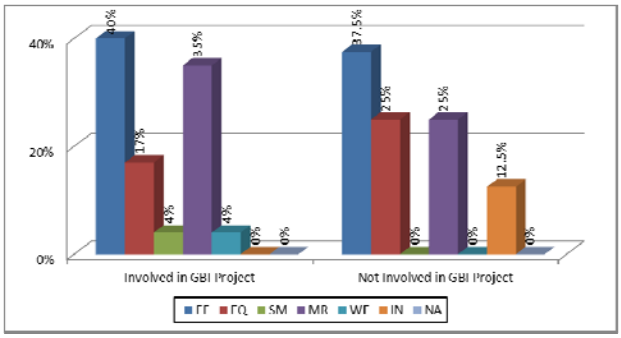

Fig. 10 High and double-tier roof using materials with good thermal properties.

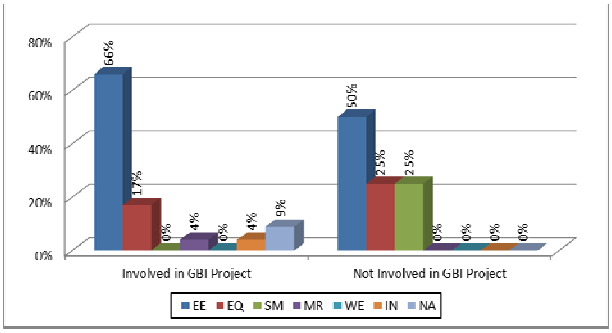

Fig. 11 Large roof overhangs and low wall height reducing the vertical areas of the house exposed to solar radiation.

Nevertheless, Fig. 12 (house is oriented towards Mecca (east-west) reduces direct solar radiation) shows that 50% of the respondents not involved in any GBI project prefer to choose SM criteria while 65% from another group of respondents choose EE. It is anticipated by the author that this result will occur depend on the perception of respondents against this component.

For Fig. 13 (random arrangement of TMH within village area permit path of winds), Fig. 14 (situated nearby the river as a means of transportation), Fig. 15 (minimum intervention towards surrounding area in construction) and Fig. 16 (lush vegetation and trees inside the house compound provide shade and coolness), it is quite clear that majority of respondent agreed at the same outcome to decide on SM criteria. However, from the total of 31 respondents, 6 respondents (19%) choose NA for Fig. 13 which is the highest NA criteria compare to the other components. This occurrence happened because some respondents probably think that the component is not as important as the others.

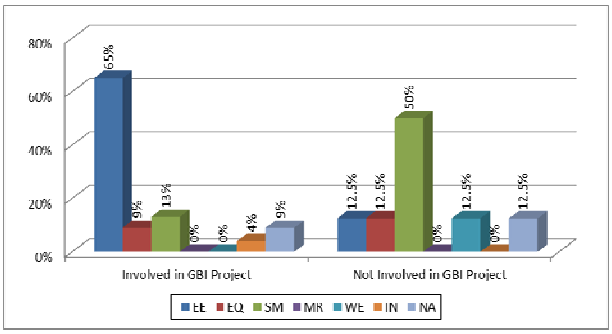

Fig. 12 House is oriented towards Mecca (east-west) reduces direct solar radiation.

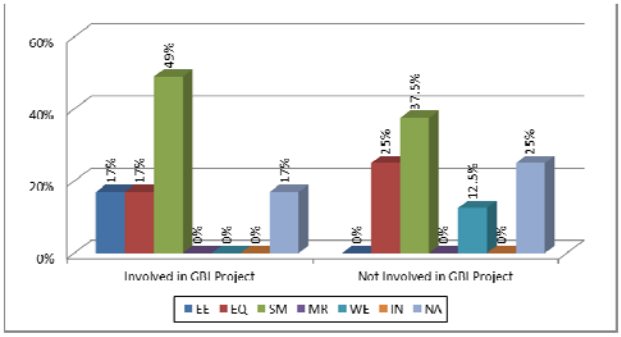

Fig. 13 Random arrangement of TMH within village area permit path of winds.

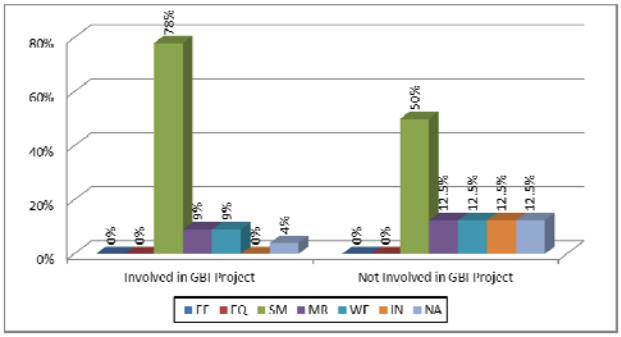

Fig. 14 Situated nearby the river as a means of transportation.

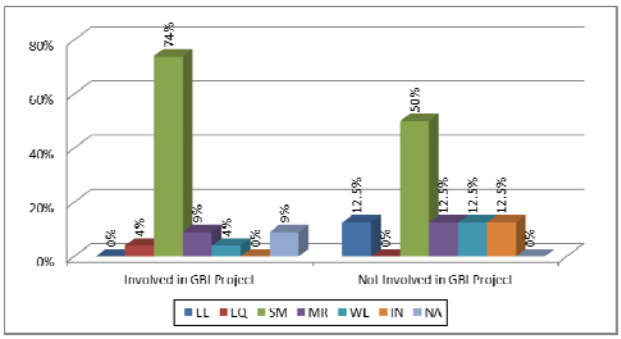

Fig. 15 Minimum intervention towards surrounding area in construction.

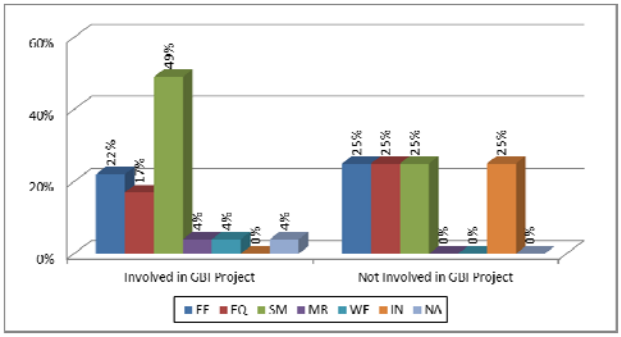

Fig. 16 Lush vegetation and trees inside the house compound provide shade and coolness.

On the other hand, MR criteria is selected for Fig. 17 (regional materials used for construction), Fig. 18 (materials used in TMH are low carbon emission) and Fig. 19 (lightweight and prefabricated construction using modular method allows flexibility in designing according to the needs).

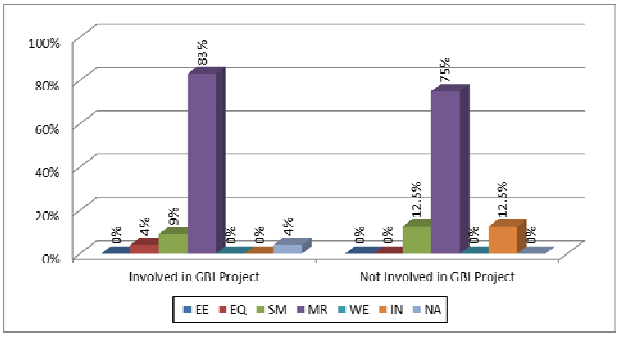

Fig. 17 Regional materials used for construction.

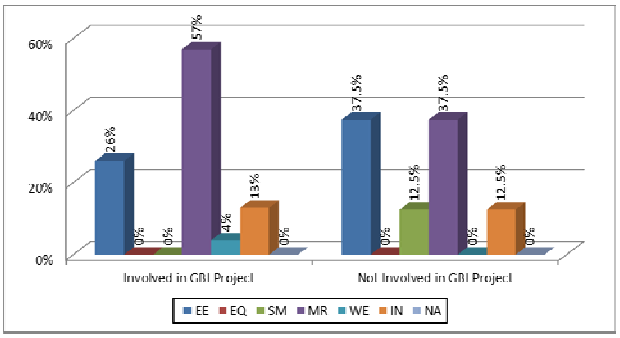

Fig. 18 Materials used in TMH are low carbon emission.

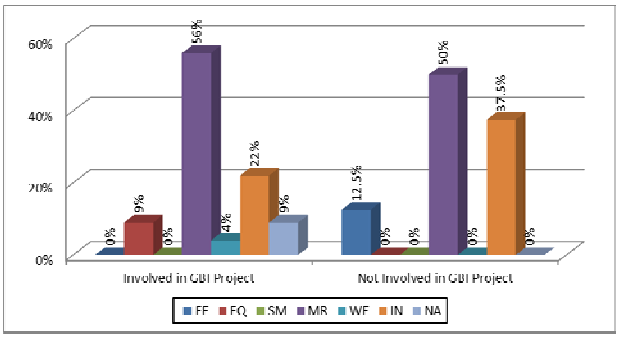

Fig. 19 Lightweight and prefabricated construction using modular method allows flexibility in designing according to the needs.

4. Conclusion

As a conclusion, in this chapter provide initial investigation in order to identify the key elements of sustainability in traditional Malay house. This chapter also defined clearly the objective, significance, scope, limitation and overview of this research. Furthermore, this chapter has outlined the general structure and the step-by-step method that have been undertaken in order to uncover the appropriate findings in the research. All the findings that have been collected would be followed with relevant analysis. It is hoped that the conclusion and recommendations towards the end of the main research body would become beneficial and would encourage future researches of similar nature in other parts of the country.

Based on the findings, the result tends to support the opinion that the GBI assessment criteria such as energy efficiency, indoor environmental quality, material and resources, sustainable site planning and management, water efficiency and innovation also suitable to evaluate TMH sustainability. Most of the identified TMH sustainability components can be attributed with those GBI criteria. These sustainability components are very important to ensure that TMH can achieve GBI certified building. Most of the respondents agree that it is essential to measure TMH sustainability. This is because it can work as a prove that TMH is still relevant as the cultural heritage of the Malays and in Malaysia.

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Modern Environmental Science and Engineering (ISSN 2333-2581)
September 2017, Volume 3, No. 9, pp. 632-643
Doi: 10.15341/mese(2333-2581)/09.03.2017/004
Academic Star Publishing Company, 2017
www.academicstar.us

Ecological and Chemical Analysis of Heavy Metal Transduction in *Salix exigua* on the Animas and Florida Rivers

Magena Marzonie, Cynthia Dott, and Callie Cole
Fort Lewis College, Durango, Colorado USA

Abstract: On August 5th, 2015, an accident from the Gold King Mine in Silverton, Colorado initiated the release of three million gallons of heavy metals into the Animas River. As heavy metals have toxic effects in high concentrations over time, it is extremely important to quantify the amounts of heavy metals in both the water itself, as well as surrounding riparian zones. This study inquired as to whether heavy metals were present in *Salix exigua*, or coyote willow, which makes up a large portion of the riparian biota in Southwest Colorado. Samples were taken from three sites, at Oxbow Park and Preserve and Trimble Lane on the Animas River, as well as from a control site on the Florida River. Six metals, including aluminum, zinc, cadmium, manganese, barium, and iron, were quantified in root and leaf samples to account for the fate and transport into riparian plants. As bioaccumulation of metals in ecosystems can have effects in many organisms, assessing the concentrations in the flora surrounding the river is essential to accounting for all aspects of river health. Metals were found to be significantly higher in roots compared to shoots, across all sites. Furthermore, the Animas River had significantly higher concentrations of heavy metals than the control site. Specifically, Oxbow Park and Preserve had the highest levels resulting from the specific geomorphology of the river section. This pilot study was essential for the quantification of heavy metal concentrations in the Animas River and will gain insight to the current ecological health post-mine spill reflecting short-term effects. It may also serve as baseline data for future studies accounting for plant health in this area that could quantify long-term effects of acid mine drainage after the Gold King mine spill.

Key words: acid mine drainage, heavy metal analysis, bioaccumulation, riparian plants, Gold King mine spill

1. Introduction

Acid mine drainage and the effects of heavy metals within both aquatic and riparian ecosystems are being brought to the attention of scientists and communities all over the United States. With the high frequency of mine spills and acid mine drainage, it is essential that we understand the short and long-term effects of heavy metals in river systems. When oxygenated water comes into contact with mine tailings containing iron sulfide, the chemical reaction causes the formation of sulfuric acid which contaminates the water. Sulfuric acid both increases the acidity of the water and leads to other heavy metals entering the solution in either a dissolved or colloidal form that would not have been present otherwise [1]. While dissolved forms of heavy metals cause a more negative impact than the precipitate form, the abundance of heavy metals such as iron, arsenic, cadmium, lead, and aluminium are all of serious environmental concern regardless of their fate and transport mechanisms, thereby representing a great challenge with regards to acid mine drainage management [2].

In light of the recent 2015 Gold King mine spill that washed three million gallons of water containing high levels of heavy metals into the Animas River, there is no better time to investigate the effects of heavy metal

Corresponding author: Magena Marzonie, Bachelor of Science, Studying for Masters of Science in Marine Biology and Ecology; research areas/interests: riparian ecology, marine biology. E-mail: magena.marzonie@my.jcu.edu.au.

pollutants on this river and its underlying ecology [3]. By looking at heavy metal uptake in plants within multiple zones and locations of the river, we can identify what areas of the Animas River have been most affected by the spill and quantify observable differences in terms of stream gradient and morphology.

1.1 Current Status of Mines and Remediation Efforts

Acid mine drainage is a major cause of river pollution in many countries with both historic and current mining practices. The preferred treatment option is preventing the formation and migration of acid mine drainage from its source; however, this is not always a feasible method. If prevention is possible, this generally involves either flooding or sealing of mines, land-based storage of mine tailings, or underwater storage of mine tailings [4]. If prevention is not a feasible method, the next step is some form of remediation, usually involving a biological or chemical mechanism to neutralize acid mine drainage and remove heavy metals out of solution and into a solid, less harmful form to biota. Remediation can use abiotic or biotic methods, but most commonly involves the addition of a chemical-neutralizing agent (abiotic). Alkaline material added to an acidic environment acts as a buffer and accelerates the rate of metal oxidation, thereby balancing the pH of the river. This helps precipitate heavy metals out of solution, so they are not in their dissolved form and are less dangerous to both humans and the environment as a whole. Disadvantages to these techniques are that they are expensive, ineffective, and typically create a toxic chemical sludge that is difficult to remove from the ecosystem [4, 5].

1.2 Effects of Acid Mine Drainage on Ecosystems and Vegetation

As acid mine drainage gains more attention as a large environmental issue, the effects on ecosystems are being studied in more depth. Major impact areas include lakes, estuaries, coastal waters, and the particular focus of this study: rivers. The effects of acid mine drainage are sorted into four categories: metal toxicity, sedimentation, acidity, and salinization. While all are important, most studies focus on metal toxicity as it poses the most direct effects on ecosystem health and resiliency. Some of the most detrimental effects of heavy metal toxicity on an ecosystem generally include habitat modification, niche loss, bioaccumulation within a food chain, losses of food source, and ultimately elimination of sensitive species [2]. The impact of acid mine drainage is difficult to quantify and predict, particularly in continuously flowing waters such as rivers. In response, the US Agency for Toxic Substances and Disease Registry lists lead, mercury, and arsenic as the top first, second, and third most hazardous metals, respectively. As heavy metals bioaccumulate in smaller organisms such as macroinvertebrates and plants, higher organisms in the food chain such as birds, herbivores, and even humans will start to experience biomagnification of these heavy metals as well [6].

Heavy metals are not simply stored in the sediment of rivers, nor do they merely continue flowing forever through the water. Plants that are present within a riparian zone experience bioaccumulation of heavy metals through root contact with sediment, soil, and water over time. This is an important concept to highlight, as not only aquatic organisms experience effects, but many organisms within the adjacent riparian zones as well [7]. One recent study correlated increased levels of certain heavy metals, such as zinc, copper, and lead, to a decrease in root biomass in the genus *Brassica*. Other general effects that heavy metals have on plants include a decreased rate of photosynthesis, decrease in overall water content, and stunted growth of an entire plant, especially within the roots [8]. As vegetation is an important source of food, shelter, and detritus in a riparian and aquatic ecosystem, if plants are being affected by heavy metal uptake, this will reflect upon many organisms within an ecosystem.

Many plants transduce heavy metals from their roots into both their shoots and leaves, which is important in understanding the mechanisms by which acid mine drainage moves out of the water and into the riparian zone [1].

The amount of heavy metals present within an aquatic or riparian plant is not solely determined by the amount of that metal in the water, sediment, or soil. The limiting factor, instead, is the metal tolerance of the plants themselves [8]. Plants have different mechanisms and genes that allow for increased solubility of metals into the roots. Furthermore, some riparian plants have transport proteins that move metals into root cells, and eventually the vascular system and ultimately leaf cells [8]. This diversity within plant genetics explains why many plants may have high levels of a particular metal and the ability to translocate these metals into shoots and leaves, while other plants cannot tolerate high levels whatsoever. For example, pine pennycress (*Thlaspi)* thrives on soils with high levels of cadmium and zinc. After observing the molecular physiology, researchers found that key gene sites for zinc transport were very stimulated in this plant in comparison with other species [9].

Knowing that plants have different tolerances and mechanisms for taking up metals can help increase our understanding of variation within the community and assess the overall health of the ecosystem.

1.3 Salix spp. and Heavy Metal Transduction

Because different species have varying abilities in both uptake and transduction of metals, it would be most interesting to focus on a plant with potential to uptake relatively high amounts of heavy metals considering the acid mine drainage problem in this region. The willow family, *Salicaceae*, have been extensively studied regarding their unique ability to transduce more heavy metals in comparison to other riparian species. In one study, *Salix exigua*, or coyote willow, appeared to have the highest capacity of four species to uptake, translocate and accumulate contaminants from a river [10]. Another study found that *Salix* species in general were much more likely to absorb heavy metals from the environment because they are fast growing, have better evapotranspirational abilities, and are deep-rooting phreatic trees, meaning they have the capability to reach contaminated groundwater [11].

In addition to this research, many studies are now focusing on the relationship between bacteria in the soil and the ability for willows to translocate more heavy metals than other plants in the same community. There is increasing evidence that rhizosphere bacteria may contribute to the metal extraction process in plants, although the mechanism behind this relationship is not well understood. This may, in part, explain why willows have a higher transduction ability, particularly with certain heavy metals such as cadmium and zinc [11].

With regards to this evidence for heavy metal transduction, as well as the fact that *Salix* species are abundant in the San Juan region, coyote willow was the plant of interest of this study to better understand the riparian communities of the southwest, as well as their responses to unnaturally high heavy metal concentrations. Implementing a heavy metal study on coyote willows in different zones and locations of the Animas River in response to the Gold King Mine spill allowed us to gather baseline data needed for determining the health of the river and will serve as a template for future studies on abandoned mines and their long-term effects on plant and river ecology.

Since plants serve as bioindicators for entire ecosystems, quantifying their heavy metal uptake in a metal polluted area may help scientists reflect on what areas of the water table are under the most distress [12]. Looking at three spatially unique riparian zones and using multiple study sites helped us characterize the fate and transport of heavy metals, whether they are harming riparian plants, and what future responsibilities we have to contribute to the resiliency of the Animas river.

2. Methods

2.1 Study Sites

Three study sites were chosen for the collection of *S. exigua* within the San Juan watershed. The first two sites were on the Animas River, a 126-mile long river, which flows from headwaters at Silverton, Colorado, eventually converging with the San Juan River in Northern New Mexico (Fig. 1). The first study site was located 5.3 miles south of Baker's Bridge, accessed via Trimble Lane, as the highest amounts of heavy metals were found close to Baker's Bridge post-mine spill. Based on limited presence of willows at the Baker's Bridge site, this was the closest accessible area with presence of *S. exigua.* The second study site was located 7.1 miles south of this site, at Oxbow Park and Preserve. This stretch of the river is characterized with meandering bends and less gradient than that of Baker's Bridge, attributing to the heavy sediment build-up at this position of the river. Because these two reaches of the Animas River have unique geomorphology, they were chosen to observe the spatial differences in heavy metal concentrations on the Animas River.

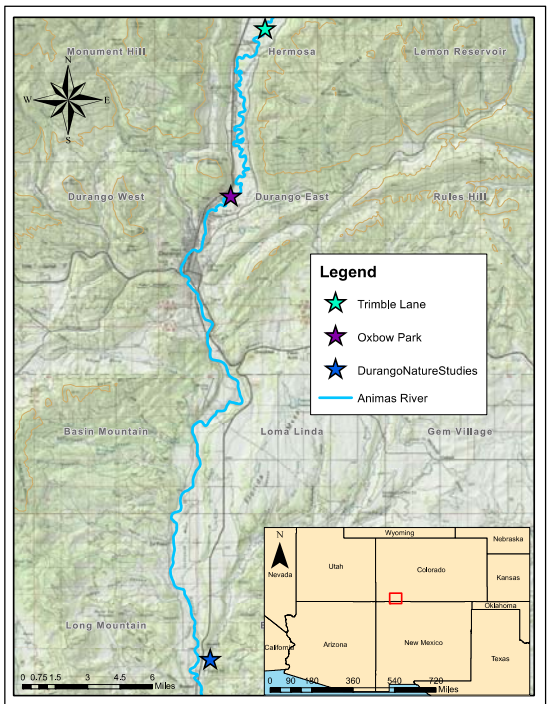


Fig. 1 Research study sites including Trimble Lane, Oxbow Park, and Durango Nature Studies.

The Florida River served as a control site, located at Durango Nature Studies, 12 miles south of Durango (Fig. 1). The Florida River is a 61-mile long tributary of the Animas River that is sourced from Lillie Lake in the Weminuche Wilderness. The Animas River had significant mining activity based in Silverton, Colorado, where the headwaters are found. In contrast, the Florida River has no past mining history. This made the Florida River an excellent control to add extra support when explaining how much of the metal concentrations in the Animas River are due to the mine spill versus natural environmental composition. Both rivers are heavily influenced by annual snowmelt higher up in the mountains during the spring and summer, as well as a monsoon season in the late summer to early fall [13].

2.2 Field Collection

The main focus of this study was to sample heavy metals in root and leaf samples of *S. exigua* to first see if there were any heavy metals present in these riparian plants. Furthermore, the question of interest was what parts of the plants had the highest concentrations amongst the different study sites and zones. At each study site, three zones were identified (Fig. 2); the first zone was classified with young willow roots, in closest proximity to the river. Leaves of the younger willows composed the second zone, and mature, established willows made up the third zone, farthest from the river. This allowed us to observe how the willows were taking up heavy metals both temporally over their life span, and spatially in relation to the river.

A preliminary test run was carried out before the main research study at Oxbow Park and Preserve to ensure that the willows had at least some form of heavy metal concentrations before complete sample collection. Two samples of the willow roots in the first zone and two samples in the second zone were collected and analyzed chemically using the MP-AES spectrometer before the initial study was thoroughly established. The preliminary test run concluded levels

Fig. 2 The three zones chosen for field sample collection, illustrating the different sample types (roots, young leaves, and old leaves) corresponding with proximity to the river (zones 1, 2 and 3, respectively). This image is from one of the three study areas, Oxbow Park and Preserve.

of six different heavy metals, so the full field collection proceeded.

Following the preliminary test runs, two 12-meter transects were set up with chaining pins at each site per zone, running parallel to the river. Four samples per zone were taken to ensure enough replication in the experiment. To account for a larger spatial distribution, and to avoid significantly damaging the willow population, three leaves or roots were clipped from each plant per meter. Each meter, a willow was sampled closest to the meter mark. This allowed for the study to account for a larger proportion of the population size by taking leaves or roots from multiple willows. Root samples were stored in Ziploc bags and leaf samples were added to brown paper bags. All samples were labelled according to the location and sample number. This process was repeated once on each transect to account for more variability. The process was repeated for each zone by moving each transect south of the original transect. The distance moved was tentative to the area sampled, as some areas were limited by topography or amount of willows present. This method allowed for four samples per zone, and twelve overall per site. The distance and elevation between each zone was measured to account for the distance and vertical elevation differences.

After harvesting the willows, all samples were stored in the drying oven in brown paper bags for at least 48 hours to ensure there was no water content in the samples before chemical analysis was performed.

2.3 Chemical Analysis

2.3.1 Plant Digestion

After all plant samples were dried for at least 48 hours, root and leaf samples were transported to the analytical laboratory for the plant digestion process. Each site's samples were digested separately, with the addition of a standard reference material, or SRM. The SRM provided was a sample of NIST tomato leaves, which included known amounts of heavy metals, and allowed for the analysis method to be validated for plant matrices. Each sample was separately ground using a mortar and pestle, and 0.5 grams of each sample were weighed and transferred into a polypropyelene digestion vial. The sample number and biomass were recorded on each tube. From there, the digestion process proceeded, in which three reagents were all used in various dilutions to digest the samples: nitric acid, hydrogen peroxide, and hydrochloric acid. Following the addition of a reagent, the samples were heated on a ModBlock at 93 degrees C in different intervals depending on which reagent was added. After the digestion process, each sample was individually filtered with a 0.45 micron syringe filter apparatus into a volumetric flask and diluted to 50 mL with 1% nitric acid in distilled water (EPA Method 3050B).

Calibration standards were prepared at various concentrations (100, 200, 500, 700, and 1000 ppb) for each heavy metal being tested, through the sequential dilution of Agilent heavy metal standards. This allowed for the external calibration of the MP-AES instrumental response to a range of heavy metal concentrations.

2.3.2 Atomic Emission Analysis

Following the acid digestion of plant samples, which solubilized the heavy metals, the samples were ready to be analyzed with the MP-AES 4200 instrument. Each sample was separately analyzed by plastic tubing that

would automatically uptake each individual sample. A blank solution of 1% nitric acid in distilled water was tested in between any samples to rinse the apparatus to avoid cross-contamination in between samples.

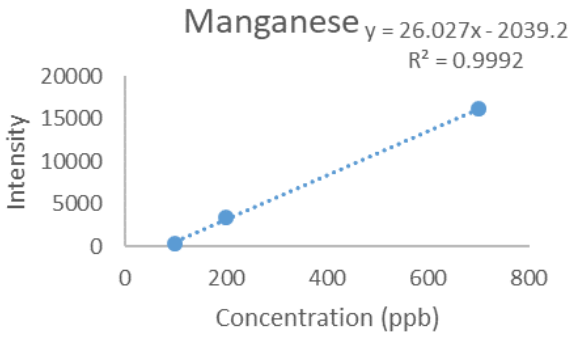
The MP-AES ran almost entirely on compressed air, coupled with a nitrogen generator, which removed all oxygen from the machine. The nitrogen allowed for a plasma that generated a high intensity emission line. Samples were passed through a nebulizer which vaporized each sample. From there, they were passed through a high heat plasma, which atomized the sample, allowing the heavy metals of the sample to emit photons at predictable wavelengths and measurable intensities. Photons with wavelengths characteristic for each element of interest were then measured by a CCD detector [14]. Each sample was tested by the instrument ten times per trial, increasing reliability of the results. The samples were tested for six heavy metals: zinc, manganese, iron, cadmium, aluminium, and barium.

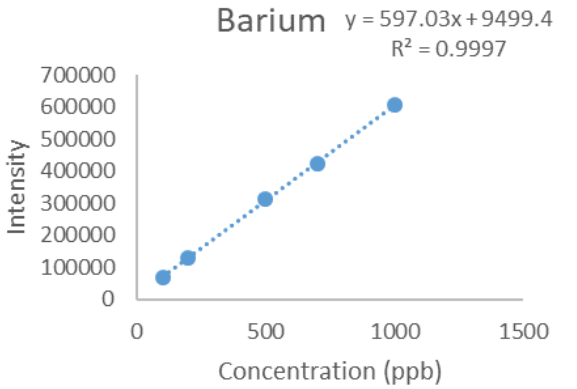
2.4 Data Analysis

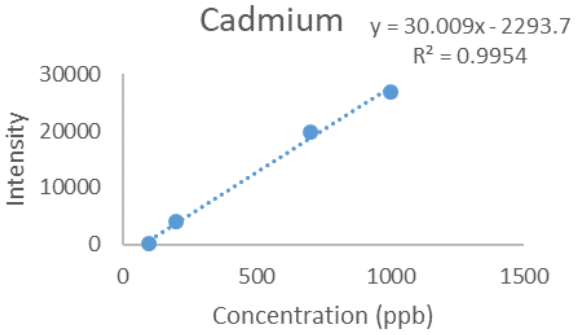
Data analysis was performed using Microsoft Office Excel after all heavy metal concentrations were recorded. Data was exported from the MP-AES 4200 software into Microsoft Excel, and actual concentrations and standard deviations were calculated. A two-way ANOVA test was performed using SPSS to account for any statistically significant data between sites, zones, as well as site-zone interactions. A p-value of 0.10 was used to conduct analyses as natural variation is typically higher in an environmental setting. In addition to this, high variability was observed between individual samples, as the metals are typically parts per billion, so even a small change can have a large effect on these small values.

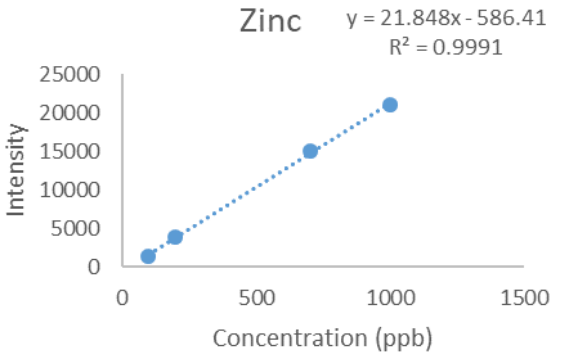
2.5 Calibrations and Corrections

Before any of the experimental data was analysed, the calibration standards were plotted to ensure a high R-squared value. This reassured us that the MP-AES









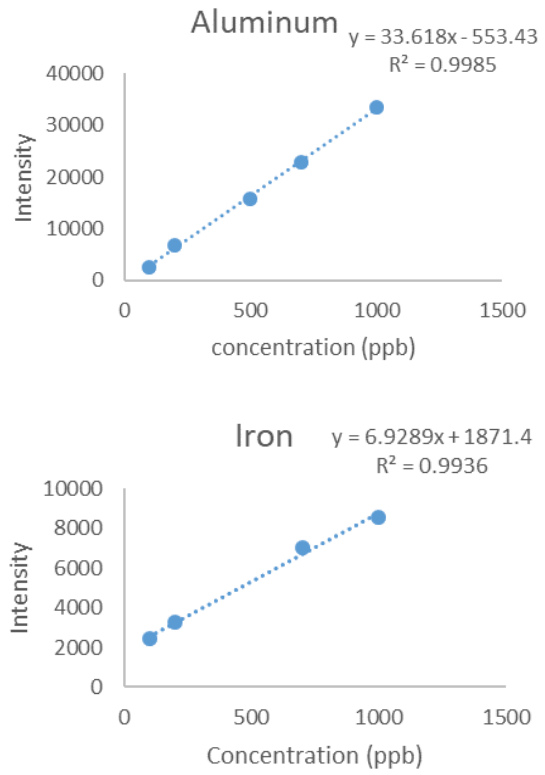


Fig. 3 Calibration curves for all six heavy metals that were analyzed. Calibration solutions were prepared for 100, 200, 500, 700, 1000 ppb, respectively using known amounts of Agilent heavy metals that were diluted using 1% nitric acid in deionized water.

Table 1 Standard reference material corrected concentration values. These values were applied to experimental plant data to correct for instrumental error. The average percent errors were used to determine if the heavy metals in experimental samples should be analyzed.

Element	Actual value	Experimental value	Average % error
Al	598	206.7	-45.3
Cd	1.5	11.8	-1.5
Ba	63	15.8	-12.0
Zn	30.9	81.5	-1.6
Fe	368	34.2	-0.2
Mn	246	133.6	-1.2

4200 was properly calibrated. All six heavy metals at this point had an R-squared value of over 99%, allowing greater assurance for accuracy within the plant sample results. The MP-AES instrument took measurements in parts per billion, which were then translated into mg/kg taking both the original dilution factor (0.05 L), as well as the mass per each sample, into account.

A correction factor was made for each plant sample as standard reference materials were digested with the experimental samples. The correction factor was determined based upon the known amounts of heavy metals in the standard reference material compared to the experimental results from the standard reference material. As the percent errors for aluminium and barium were fairly high, the experimental data for these two elements were not used to assess the heavy metal concentrations of plants on the Animas River.

Aluminium concentrations far exceeded the calibration standards prepared, as the standards could only accurately measure concentrations from 100 parts per billion to 1000 parts per billion. On the other hand, barium was also excluded from data analyses as almost all concentrations were below 100 parts per billion, of which no calibration standards were prepared. Therefore, aluminium and barium were removed from further chemical analyses of the plant samples.

3. Results

Chemical analysis revealed that there were, in fact, heavy metals present in samples at all sites, including the control river. Regardless of site or zone, there was always the same hierarchy of heavy metal concentrations observed: manganese at highest, followed by iron, then zinc, and lastly cadmium (Figs. 4-6). Site comparisons indicate that Oxbow Park and Preserve had the highest overall concentrations of heavy metals, compared with both Trimble Lane and the Durango Nature Studies sites. For example, average manganese concentrations were nearly twice as high as concentrations at the other two sites when not accounting for variation across zones. This trend was observed for cadmium and iron as well, with the exception of zinc, which did not have an apparent site effect (Figs. 4-6).

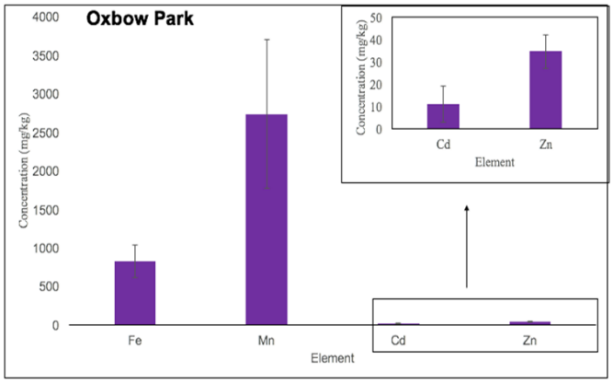


Fig. 4 Average concentrations of iron, manganese, cadmium and zinc (+/- SEM) at Oxbow Park and Preserve.

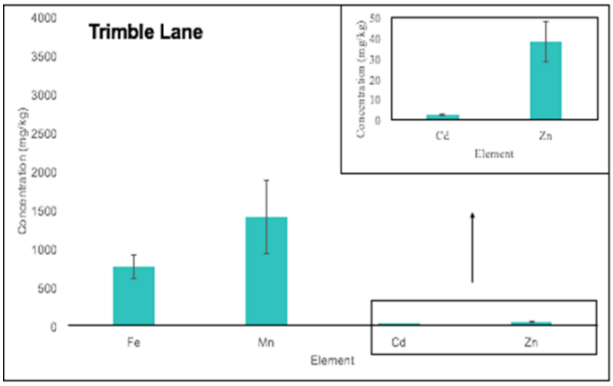


Fig. 5 Average concentrations of iron, manganese, cadmium and zinc (+/- SEM) at Trimble Lane.

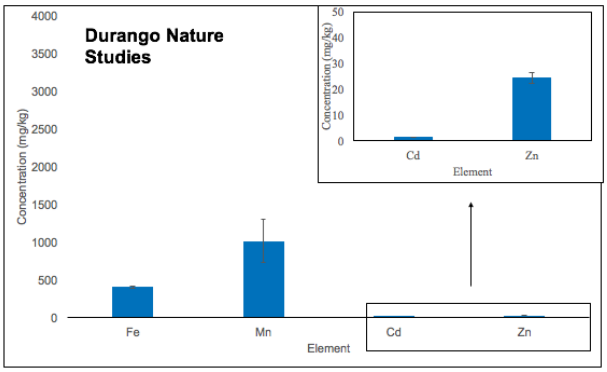


Fig. 6 Average concentrations of iron, manganese, cadmium and zinc (+/- SEM) at the Durango Nature Studies, the control site.

Again, the chemical analyses did show heavy metals for each of the four heavy metals tested, all in fluctuating quantities. Trimble Lane had higher concentrations for all heavy metals than that of the control site; however, nearly all averages at Trimble Lane were lower than at Oxbow Park and Preserve.

For both treatment sites, Oxbow and Trimble, roots always exhibited the highest concentrations of metals, followed by young leaves, then finally mature leaves, (Fig. 9). In contrast, at Durango Nature Studies, there was not always a clear trend. Most of the metals were fairly ubiquitous in concentrations across the three zones (Figs. 8-10). The only metal that exhibited the normal decreasing trend moving away from the river was manganese (Fig. 7).

Looking at synergistic effects, the site-zone interactions were significantly different for each heavy metal, including manganese, zinc, and iron, indicating that there is a correlation between each specific site, the relative zones within them and the quantity of each heavy metal ($p < 0.0001$).

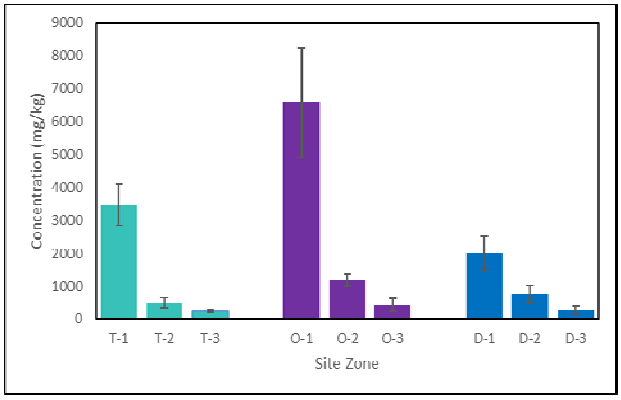


Fig. 7 Average concentrations of manganese (+/- SEM) at the three sites and separated out into the three different zones. T indicates the first site at Trimble Lane, O indicates the second site at Oxbow Park and Preserve, and D indicates the control site at Durango Nature Studies.

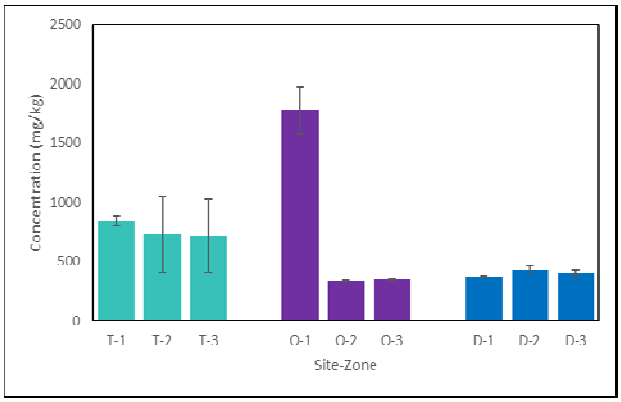


Fig. 8 Average concentrations of iron (+/- SEM) in mg/kg across the three sites and zones. For example, O-1 refers to Oxbow Park, Zone 1.

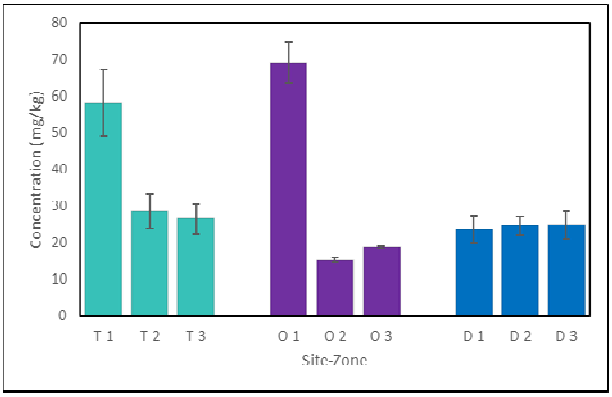


Fig. 9 Average concentrations of zinc (+/- SEM) across all study sites and zones. For example, D-1 refers to Durango Nature Studies, Zone 1.

3.1 Manganese

Looking just at the sites and excluding the zone factor, manganese concentrations were significantly different between Oxbow and the control site (p-value = 0.021), as well as Oxbow and Trimble (p-value = 0.087). Looking specifically at zones, there was no significance between zones 2 and 3 (young plants and mature plants, respectively) with a p-value at 0.689. However, all other zones did show significantly different amounts of manganese, including zones 1 and 2, and zones 1 and 3, respectively ($p < 0.0001$).

3.2 Iron

Iron showed fairly similar trends to manganese, with no significant difference in iron concentrations between Oxbow and Trimble sites ($p = 0.926$). In contrast, there was an overall observable difference between Trimble and the control site, Durango Nature Studies ($p = 0.068$). Oxbow and the control site, DNS, were also deemed significantly different ($p = 0.03$).

The amounts of iron varied significantly between the roots and young leaves, zones 1 and 2 ($p= 0.009$). Similarly, zones 1 and 3 displayed significance ($p = 0.008$). However, like the other metals, there was no significance between metal concentrations in zones 2 and 3 ($p = 0.998$).

3.3 Zinc

There were no statistically significant differences found between the Oxbow and Trimble sites for zinc ($p = 0.743$). The sites that varied significantly in their zinc load were the Trimble site and the control site, with a p-value of 0.012, as well as Oxbow and the control site, with a p-value of 0.063.

In regards to the differences in zinc across the three zones, there was no significance between young leaves and old leaves ($p = 0.984$). Like the other heavy metals, there was a significant difference in zinc between zones 1 and 2, as well as zones 1 and 3 ($p < 0.0001$).

3.4 Cadmium

Compared to the other metals found in the plant samples, cadmium was present in the lowest concentrations across each site. The root samples at Oxbow were significantly greater than any other zone or site; however, they also had extremely high standard error at this particular zone and site (Fig. 10).

Cadmium was the only metal that did not exhibit any significance across study sites, Oxbow and Trimble yielding a p-value of 0.364, Trimble and the control yielding a p-value of 0.993, and Oxbow and the control displaying a p-value of 0.307. Also different from the other metal trends, cadmium was the only heavy metal that did not exhibit any significance for site and zone interactions as well ($p = 0.294$).

The same pattern was observed for cadmium across the three zones. The roots and young leaves (zones 1 and 2), showed a p-value of 0.287, and the roots and old leaves (zones 1 and 3) had a p-value of 0.308. There was no significance, as expected, between the young and old leaves, with a p-value of 0.999.

4. Discussion

The concentrations of heavy metals in the Animas River compared with the Florida River indicate that the Gold King Mine Spill did, in fact, have a significant impact on the amounts of heavy metals being transported to the adjacent riparian zone of the Animas River. While all sites including the control contained the four heavy metals tested for, the two sites on the Animas River had significantly higher amounts of all

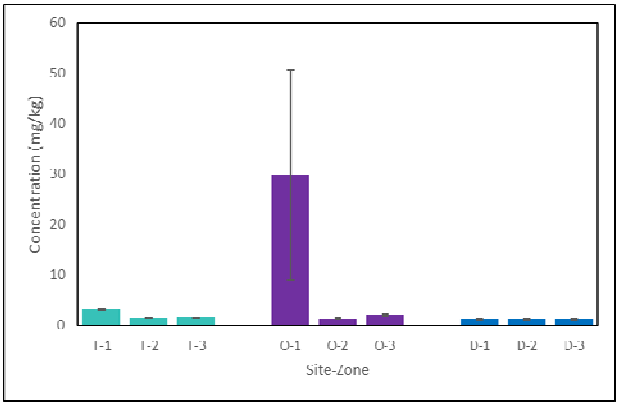


Fig. 10 Average concentrations of cadmium (+/- SEM) across all sites. Each treatment or control is subdivided into the three zones, containing roots, young leaves, and mature leaves. For example, T-1 refers to Trimble site, Zone 1.

heavy metals than the Florida River, with the exception of zinc. Because the treatments were significantly higher, this is evidence that past mining activity has had deleterious effects on the riparian organisms that rely on adjacent water sources for life.

Another indication that the Gold King Mine Spill had a significant and unnatural ecological impact was the spike in heavy metal concentrations in the roots on the Animas River compared to the Florida River. This spike in metals is synchronized with the release of three million gallons of heavy metals. Juxtapose this to the relatively unchanging levels of heavy metals on the control site, indicating that the natural metals in the environment are being taken up at a more constant rate, as there is no mining activity above the Florida River. Because the levels stay ubiquitous between zones on the Florida River, this is evidence that the metals have been taken up at a constant rate and have not experienced a plume of metals, as did the Animas River.

Another profound finding was the change in heavy metal concentrations in the samples relative to various stream morphologies at a given site. As Oxbow Park is a slower river flow with a meandering morphology, sediment deposition accumulates in higher amounts on the point bars. After the plume, the high concentrations of heavy metals were deposited on these point bars where *S. exigua* tends to grow in abundance compared with other reaches of the river. This is reflected by water quality tests that were conducted right after the Gold King Mine spill, which displayed highest levels of contaminants at Baker's Bridge and Oxbow Park [15]. This study showed Oxbow Park to always have significantly higher metal loads in samples compared to the control group, while Trimble Lane was not always different from the control. Again, this may be due to the faster water velocity and streamlined features that make up the area around the Trimble site. Looking deeper into this study, the most apparent trend observed was the significantly higher concentrations of all heavy metals in the roots, compared to the leaves. This was evident, regardless of which site the plants were located at, or which metal was being tested for. When compared using a 2-way ANOVA, the differences in concentrations between the root samples (zone 1) and the leaf samples (zones 2 and 3), were almost always statistically significantly different. The only metal tested that did not show significantly different concentrations between roots and leaves was cadmium, which may be due to the relatively low concentrations observed in the plants. The levels may not have been high enough to show any trends. Furthermore, the levels of aluminium, manganese and iron may have been so much higher than cadmium that it did not allow for the cadmium to be taken up in a greater portion on the Animas River.

The overall trend of higher metal concentrations observed in the roots can be supported by past data, particularly *Salix spp.* Since roots are the first part of a plant to come into contact with the metal ions, and transport of the heavy metals to shoots is relatively low, they typically accumulate higher concentrations which are then stored in the roots [16]. This is most likely a mechanism evolved to protect the shoot, and therefore, the photosynthetic pathways of the plant from being affected [16]. There were never significant differences between the young plant leaves and the mature plant leaves, which may mean that there is not a lot of transduction occurring from the roots to the shoots,

soon after the Gold King Mine Spill. In contrast, the control river did not exhibit these same patterns; this could indicate that natural metals have been taken up for many years and are ubiquitous across the roots and shoots. The overwhelming amount in the roots on the Animas River suggests that the plume has fully saturated the roots with heavy metal content and does highlight the need to keep monitoring these concentrations in the upcoming years.

Another interesting trend observed in this study was the variation of concentrations between metals. Clearly, the metals were all taken up at different levels, as the concentrations vary in the water itself. Aluminium and manganese are much higher in the water, which makes sense that these were the two highest metals observed [3]. Furthermore, metals are taken up in different amounts depending on both the tolerance and nutrient needs of the plant. Metals such as zinc and manganese are needed as secondary metabolites, so willows tend to uptake higher quantities of these metals [7]. In addition, *S. exigua* has been noted to have a high tolerance for metals such as cadmium and zinc, which may be due to their symbiotic relationship with rhizosphere bacteria which has a high affinity for these metals and allows for better extraction of these metals from the sediment into the roots [11]. This could help better explain some of the trends we see with varying concentrations of metals within the plants.

Future studies would be beneficial to obtaining more data, and thus, more evidence of elevated heavy metals on the Animas River. Because there were only twelve samples per site and four samples per zone, the variation in heavy metal concentrations was relatively high, even within each individual treatment. For a similar study in the future, perhaps eliminating one variable may help increase the replication factor. By just looking at roots versus leaves, or looking at two sites instead of three, more samples could be taken to reduce the large standard error that was observed in the results of this study. It would also be of interest to take samples from the same site over the next decade, in order to see if any transduction is occurring from the roots to the shoots. The samples on the Animas River may end up levelling out, similar to that of the Florida River if another large mine spill does not occur. Particularly regarding phytoremediaton efforts, if the roots are transporting heavy metals to the leaves in high quantities, *S. exigua* could be a potential natural resource for remediation efforts that could eliminate chemical treatment of the water.

The plants on the Animas River are undoubtedly being exposed to higher heavy metal concentrations than on similar rivers in the Southwest region. This reflects that anthropogenic effects are not only causing poor water quality; the effects are being amplified into the riparian zones, and potentially the entire ecosystem in this area. While heavy metals are more prevalent in this area considering the environmental composition, it is our duty to make a conscious effort to reduce the amount of metal pollutants that are being secreted into water sources and to continue to monitor and mitigate the amounts of metals that are getting transported into both the aquatic and riparian zones of this region.

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Modern Environmental Science and Engineering (ISSN 2333-2581)
September 2017, Volume 3, No. 9, pp. 644-652
Doi: 10.15341/mese(2333-2581)/09.03.2017/005
Academic Star Publishing Company, 2017
www.academicstar.us

Measurement of the Heat Transfer Coefficient in Case of Impinging Synthetic Jet

Petra Dancova, Tomas Vit, and Jan Novosad
Technical University of Liberec, Czech Republic

Abstract: The paper deals with the measurement of a heat transfer coefficient caused by an impinging synthetic jet. The heat transfer coefficient is measured using the thermoanemometry in a constant temperature mode (CTA). Experiments are based on measurement and evaluation of heat flux from the heated probe (placed on the heated plate) to the surrounding fluid. The probe temperature is maintained similar to the temperature of the plate to minimalize the conductive heat flux from the probe to the plate. Experiments are performed with three different overheat ratios of the thermoanemometric probe.

The experimental results are the starting point for the CFD simulations. CFD simulations are carried out in a pimpleFoam solver included in a OpenFOAM software modified by adding an energy transport equation. The simplified computational domain is defined based on the experimental setup. CFD boundary conditions are set according to the experimental data. CFD results are velocity fields in the whole computational domain. Velocity fields are confronted with experimental data to validate the developed OpenFOAM solver which will be used for next numerical investigation of heat transfer.

Key words: synthetic jet, heat transfer, thermoanemometry, OpenFOAM

1. Introduction

Subject of heat transfer intensification is heavily solved today. The topic is of great importance especially in the field of cooling of micro-electronics devices. Each electronic device generates heat that grows proportionally with the number of elements in the circuit. This heat has to be removed from the device in order to ensure its functionality within the technically permissible operating temperature and to avoid overheating defects in which some parts or whole device may be damaged. Therefore, the coolers become an important part of many devices.

Coolers, based on its principle, can be divided into three groups: (1) passive coolers are based on the increase of surface area (using ribs, lamellas or rods) and are made from materials with high thermal conductivity (as aluminium), (2) active coolers as fans are generating fluid flow from the environment, and (3) combined coolers, where the active cooler is deployed to the passive cooler and generates the flow of air passing through the passive cooler to increase the efficiency of waste heat removal. The character of the flow is of great importance also. The highest intensity of heat removal from the heat transfer surfaces is achieved when the flow could be considered as turbulent flow or impacts directly on cooled surfaces (so-called impact flow).

A very interesting example is the heat transfer (cooling) of the micro-electro-mechanical systems (MEMS) where the flow is often, due to small dimensions, laminar and therefore the heat transfer ratio is small. Example could be found in the numerical study of Timchenko et al. (2006) [1] where is performed numerical simulation of intensification of an electronic processor's cooling: the laminar airflow is heated from one-side and affected by the synthetic jet

Corresponding author: Petra Dancova, Ph.D., research areas: fluid mechanics, thermodynamics, heat transfer, boundary layers, experiments, synthetic jets. E-mail: petra.dancova@tul.cz.

from the other side. Laminar flow is disturbed by the synthetic jet (in work of Timchenko et al. (2005) the term "quasi-turbulent flow" is suggested [2]) and the transport phenomena increases. The study of Choi (2005) [3] shows how it is possible to improve processor cooling. Go and Mongia (2008) [4] investigated the hydrodynamics and thermal performance of the synthetic jets perpendicular to a confined duct bulk flow and flow across the heated surface as well. The thermal measurement was performed by a system of thermocouples. Investigation of the advanced dual piezoelectric cooling jets as microfluidic devices describes a paper of de Bock et al. (2012) [5]. Heat transfer was obtained from temperatures of a cooler, heater, inlet/outlet air, respectively, measured with the thermocouples.

Presented work is based on the research of a heat transfer on the heated plate affected by the impinging synthetic jet. A high level of turbulence intensity of the synthetic jet leads to a significant increase of the heat transfer intensity. Due to this advantage, there is a wide range of possible applications in the field of cooling highly thermally loaded parts in micro-electronics. More details about these applications can be found in, e.g., Trávníček et al. (2006 and 2010) [6, 7]. The task of impinging jets which are used for the heat/mass transfer has been studied intensively in recent years, e.g., Gillespie et al. (2006) or Arik (2007) [8, 9]. Nevertheless lot of works investigates heat transfer indirectly using naphthalene sublimation, for the summarizing study see the paper of Goldstein and Cho (1995) [10]. These types of experiments are based on the analogy between heat and mass transfer, where measured mass transfer data are transformed to the heat transfer with using the ratio, $\mathrm{Nu}/\mathrm{Sh} = (\mathrm{Pr}/\mathrm{Sc})^{\mathrm{n}}$ where Nu, Sh, Pr and Sc is Nusselt, Sherwood, Prandtl and Schmidt number, respectively. Exponent n can be found in the range of 0.33 to 0.42 in those equations.

This paper brings investigation of the heat transfer coefficient measured with thermoanemometry in a constant temperature mode. Motivation of this work was a paper of Scholten and Murray (1996) [11] which describes convective heat transfer measurement with a hot film sensor and its correction considering the influence of shear stress.

2. Experimental Setup and Methods

Synthetic jet (SJ) is generated by the periodic motion of an actuator oscillating diaphragm. In this work, the SJ actuator is driven by two actuating loudspeakers (Monacor SP 60/4). The diameter of each loudspeaker diaphragm and the actuator emitting orifice is D_D = 75 mm, D = 10 mm, respectively. The SJ impacts on the aluminium plate (with dimensions of 350×260 mm^2) in the distance H from the SJ emitting orifice (see Fig. 1 for the schematic view of the experimental arrangement). The SJ actuator is placed on a traverser, which enables setting of position in all directions, the heated plate is fixed. The heating foil (130×130 mm^2) is firmly fixed on the plate bottom side. The foil is maintained on the constant temperature which is controlled with a system of the thermocouples connected to the PID regulator. The thermocouples are fastened in a part of the plate not influenced by the impact of the SJ.

The loudspeakers are working in phase and fed with the harmonic signal. A constant input power of 3 W is used during the experiments. The actuating working frequency, discussed in paragraph 4.1, is set as 74 Hz.

A DANTEC anemometer (90C10) in a constant temperature mode is used for measurement. A direct

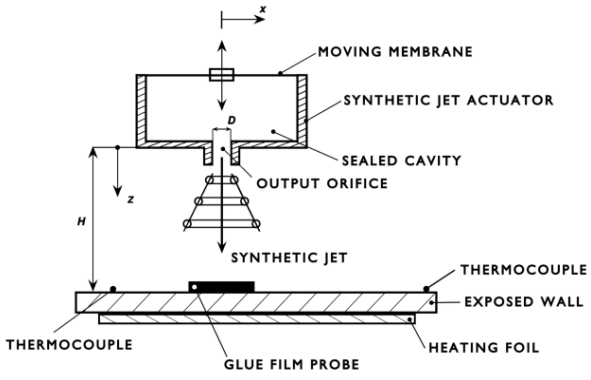


Fig. 1 Schematic view of the experimental setup.

single wire probe (55P11) is used for velocity measurements. The sampling frequency is 10 kHz and number of samples is 32,768. For the present experiments, the anemometer is calibrated in the range of (0.5-30.0) m/s. The error of the calibration due to the using of five-degree polynomial curve is less than 2%.

A glue-on film probe (DANTEC 55R47) fixed on the plate is used for heat transfer experiments. The sampling frequency and number of samples is also set as 10 kHz, 32,768, respectively. To minimalize conductive loses from the probe to the plate, the probe should be adjusted to the same temperature as is set on the plate. The probe temperature is set by the overheat ratio a.

During the velocity and heat transfer experiments, the raw data of voltage are obtained. The phase averaging of these data during one cycle is performed by the decomposition $e(t) = \bar{E} + E_p + e'$, where $\bar{E}$, E_p , and e' (V) is the time-mean, periodic and fluctuating component, respectively. It should be taken into account that the thermoanemometric probes can measure only the absolute values of the flow. As the synthetic jet consists from the suction (negative values) and extrusion (positive values), it is necessary to determine the direction of the suction by data inverting during the data analysis. All data are processed using SW Matlab and Excel.

3. CFD Modelling

The CFD model is performed with respect to the experimental setup. The open source software OpenFOAM 4.0 with standard solvers is used for simulations. Transient numerical modelling consists of solving the pressure, velocity and thermal fields in a computational domain based on the momentum and energy with respect to the mass conservation. As assuming the incompressible turbulent flow, the transient solver *pimpleFoam* is chosen as a base for the development of a newly compiled solver for investigated problem. The *pimple* algorithm for solving momentum equation is used.

The simplified computational domain was defined based on the experimental setup. The computational domain has a cylindrical shape. Dimension H corresponds to the distance between the SJ output orifice and the exposed plate. The orifice output section is chamfered by the chamfer of size 1 mm x 45°.

The computational domain with H = 50 mm and a corresponding mesh were created by using the OpenFOAM tool *blockMesh*. Fig. 2 shows the schematic view of the domain (2a) and the computational mesh (2b).

Solver *pimpleFoam* does not contain method for solving of energy equation. So, it was necessary to modified original solver by adding an energy transport equation in the form [12]:

$$\frac{\partial T}{\partial t} + \nabla \cdot (\boldsymbol{U}\, T) - \nabla \cdot D_T \nabla T = 0 \qquad (1)$$

where T (K) is thermodynamic temperature, t (s) time, and D_T (m^2/s) thermal diffusivity. Velocity vector U (m/s) consists of three components U_x, U_y, U_z. The definitions of temperature fields and thermal diffusivity are implemented into the source code of the original solver. Newly compiled solver is named as *pimpleThermalFoam*. Air, considered as incompressible gas with constant density and viscosity, is used as a fluid in the whole computational domain. Turbulent model *k-ω SST* is used for modelling the turbulence and for the simulation of heat transfer in a boundary layer.

Defined boundary conditions are *inlet* and *heated wall* (see Fig. 2a). Unmarked faces are classified into one group named as *surroundings* which represents the interface between area of interest and ambient air in the laboratory. The inlet area represents the SJ actuator emitting orifice.

Velocity is defined by harmonic function, where the velocity value in z direction is defined as:

$$U_z = A \cdot \sin(2\pi f t) + B \qquad (2)$$

where A = 23.7 m/s is the velocity amplitude, B = 1.65 m/s is the offset value, f = 74 Hz is the frequency and t (s) is time. Constants A and B are based on the

experimental data to reach good accordance with experimentally investigated velocity dependency on time. The sinusoidal curve CFD(in) in Fig. 3 represents the inlet velocity (defined by Eq. (2)). Other curves in Fig. 3 demonstrate following: EXP(or) illustrates experimental results measured at the point on the orifice axis in the distance 1 mm from the orifice output. CFD(or) shows the CFD results evaluated at the same point as is measured EXP(or).

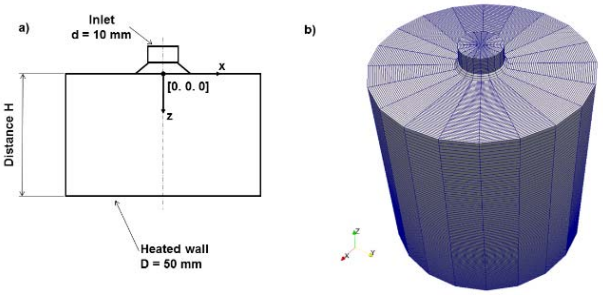


Fig. 2 Computational domain: a) geometry, b) mesh for H = 50 mm.

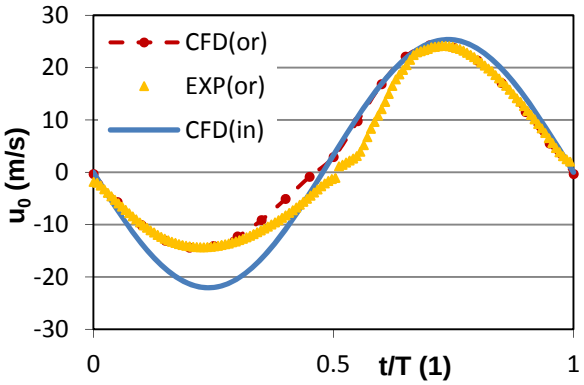


Fig. 3 Time varying velocity (CFD) compared with the experimental phased averaged velocity (EXP).

Heated plate is set as a wall with constant temperature on the surface. The temperature is the same as the maintained temperature in the experiments. Table 1 specifies the boundary conditions parameters important for the numerical model. Values which are not written in Table 1 are set with respect to the standard approaches in OpenFOAM [13].

Table 1 Boundary conditions.

Boundary	Pressure (Pa)	Velocity (m/s)	Temperature (K)
Inlet	type zero Gradient	type uniform Fixed Value uniform Value sine (see Fig. 3)	type fixed Value value uniform 296.5
Heated wall	type zero Gradient	type fixed Value value uniform (0 0 0)	type fixed Value value uniform 331
Surroundings	type fixed Value value uniform 0	type inlet Outlet	type fixed Value; value uniform 296.5

Main results from numerical simulations are velocity fields in the computational domain. The time parameter t/T is defined due to the transient solution and periodic changes at the inlet. Time parameters are set to evaluate results at t/T = (0; 0.25; 0.5; and 0.75), i.e., the beginning of suction, maximal suction, beginning and maximal extrusion, respectively.

4. Results and Discussion

4.1 Frequency Characteristics of SJ Actuator and Velocity Field Experiments

The SJ actuator works optimal near its resonance frequency, when it achieves the highest amplitude of the extrusion velocity; the mass flow rate of the fluid is maximal at the given power. Therefore, the frequency characteristic of the SJ actuator has to be performed. Frequency determination is carried out by the thermoanemometry in a constant temperature mode mode using 55P11 probe. The probe was situated in the axis of the emitting orifice (z axis) at the distance z/D = 1. Resonance frequency is investigated for electric input power of the SJ actuator of 3 W and is found in the interval of (30-100) Hz. The error of the actuator electric power settings is within 0.6%. The maximum value of voltage/velocity is found at 74 Hz. At this frequency the velocity and heat transfer experiments are carried out. Fig. 4 shows the dependence of the dimensionless velocity on the frequency, where U_{res} means the velocity value obtained on the actuator resonance/working frequency. The value of the resonance frequency does not depend on the electric

power deviations during the power supply of the actuator, as visible in Fig. 4b.

To quantify the SJ parameters, the instantaneous velocity $u_0(t)$ is measured in the actuator orifice using CTA mode. Fig. 5 shows the velocity cycles for three different actuator input powers.

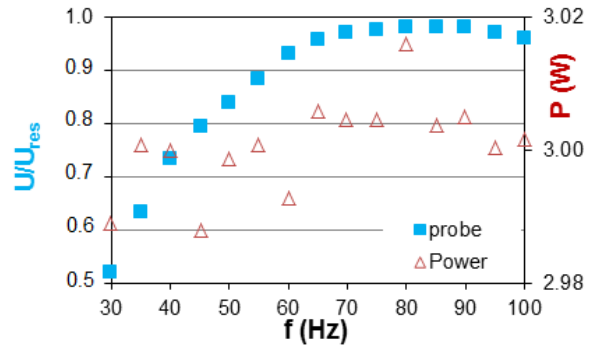
Summary of the SJ parameters is shown in Table 2. The time-mean orifice velocity U_0 and Reynolds number $\mathrm{Re_{SJ}}$ of SJ used in Table 2 are defined by Eqs. (5) and (6):

$$U_0 = {}^1\!/_T \int_0^{T_E} u_0\,(t)dt \tag{5}$$

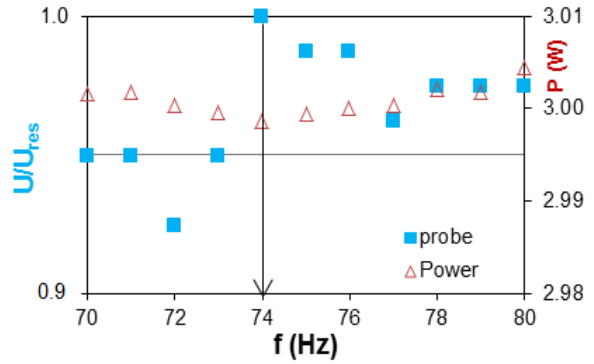
$$\mathrm{Re_{SJ}} = {}^{U_0 D}\!/_\nu \tag{6}$$

where T means the period of the cycle, i.e., $T = 1/f$ and f means the frequency, T_E means extrusion time ($T = T/2$ for the sinusoidal waveform as used in these experiments), u_0(t) is the periodical axial orifice velocity. Another important parameter named *Extrusion stroke length* can be calculated as shows by Eq. (7):

$$L_0 = {}^{U_0}\!/_f \tag{7}$$



(a)



(b)

Fig. 4 (a) Frequency characteristic of the SJ actuator (*P* = 3W) (performed with a step of 5 Hz), (b) detailed view (step of 1 Hz). Filled squares and triangles represent velocity measured with the probe, and electric power supply of the SJ actuator, respectively.

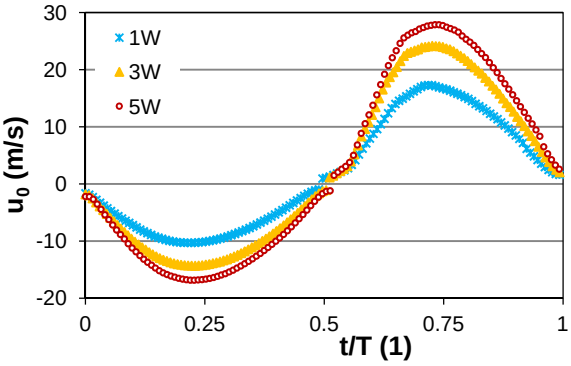


Fig. 5 Phased averaged velocity in the actuator orifice.

Fig. 6 shows the development of the phase-averaged velocity U_P with increasing distance from the actuator orifice during one cycle of SJ actuator. The development of time-mean velocity U with increasing distance from the orifice is also presented. The velocity decreases with increasing distance in z direction and at the distance z/D = 13 from the orifice the flow oscillation practically disappears (the flow can be considered as a steady jet flow).

Table 2 Summarizing of SJ parameters.

	3 W
f (Hz)	74
U_0 (m/s)	7.12
L_0/D	9.63
$\mathrm{Re_{SJ}}$	4563

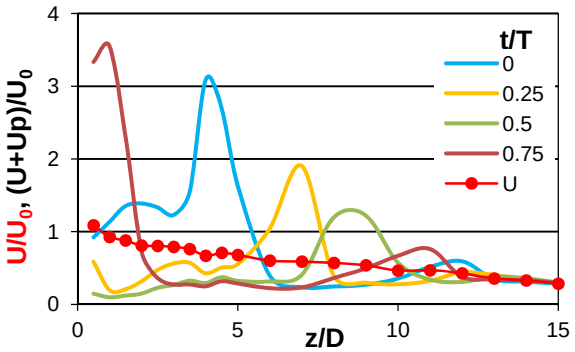


Fig. 6 Dependence of the phase-averaged velocity magnitude at different instances in the period and the time-mean velocity on the distance from the actuator orifice; *P* = 3W.

4.2 Heat Transfer Measurement

Experiments are performed with three overheat ratios a = (0.07, 0.08, and 0.12). Set values are listed see Table 3. The plate temperature should be set according to the Eq. (8) to prevent or minimalize the conductive loses from the probe to the plate.

$$T_{\text{over}} + T_{\text{a}} \geq T_{\text{wall}} \tag{8}$$

where sum of over temperature, set through the overheat ratio a, and ambient temperature gives the value of the probe wire temperature. The wire and plate temperature difference is less than 1.33°C. The inequality ">" is due to the PID regulator which sets the heating foil temperature (i.e., the temperature of the plate) within the control band.

Table 3 Temperature values settings.

Overheat ratio a	Over temperature T_{over} (°C)	Ambient temperature T_{a} (°C)	Wire temperature T_{w} (°C)	Plate temperature T_{wall} (°C)
0.07	20.83	23.5	44.33	43
0.08	23.81	23.5	47.31	46
0.12	35.71	23.5	59.21	58

Raw data, voltage, are processed with respect to the settings of the system resistance, i.e., total resistance, resistance of the probe wire and Wheatston's bridge resistance, respectively. Heat flux dissipated from the probe wire Q_{diss} (W) is then calculated in accordance with the paper of Scholten and Murray (1997) [14] as:

$$Q_{\text{diss}} = \left(E_{\text{SJ}}^2 - E_0^2\right) \frac{R_{\text{sensor}}}{\left(R_{\text{total}} + R_{\text{bridge}}\right)^2} \tag{9}$$

where E_{SJ} and E_0 (V) means voltage through the probe wire measured if the SJ works, or the SJ is off (E_0). R_{total}, R_{sensor}, and R_{bridge} (Ω) are the whole system, probe, and Wheatston's bridge resistances respectively.

The dissipated heat transfer rate is calculated as:

$$q_{\text{diss}} = \frac{Q_{\text{diss}}}{1.5 A_{\text{sensor}}} \tag{10}$$

where multiplication of the real probe wire area A_{sensor} with 1.5 gives the effective area of the sensor which is used to quantify lateral conduction within the film of the probe [15].

The Nusselt number is calculated as:

$$\text{Nu} = \frac{(q_{\text{diss}} + q_{\text{cond}}) D}{k_{\text{air}} (T_{\text{w}} - T_{\text{a}})} \tag{11}$$

where q_{cond} (W/m^2) is heat transfer rate through the probe film, D (m) diameter of the emitting orifice, and k_{air} (W/(m·K)) is mean value of thermal conductivity of air in the boundary layer. The heat transfer coefficient is evaluated as:

$$h = \frac{q_{\text{diss}} + q_{\text{cond}}}{(T_{\text{w}} - T_{\text{a}})} \tag{12}$$

Fig. 7 demonstrates dependence of the Nusselt number in the different instants of the period in different distances from the emitting orifice axis (axis z). The curves are shifted of 250 for clarify. Distribution of the phase-averaged and time-mean Nusselt number shows Fig. 8.

Fig. 9 brings the results of the time-mean values of the heat transfer coefficient measured in the distance z/D = 5. The measurement is made with three overheats ratios which corresponds to the over temperatures of 20.83°C, 23.81°C, and 35.71°C. The curves of h in Fig. 9 does not show as big difference of the dependence of h on the (T_{wall}-T_{a}) which corresponds to the expected values. Fig. 10 shows the dependence of h on the phase of actuating period. As supposed, the highest heat transfer, the highest heat transfer coefficient respectively, occurs in the phase of maximal extrusion from the orifice (t/T = 0.75).

4.3 CFD Results

The results of CFD calculations are presented in form of velocity fields. According to the experiments, the velocity on the line which is coincident with the

orifice output axis is analysed. Velocity profiles are shown in Fig. 11.

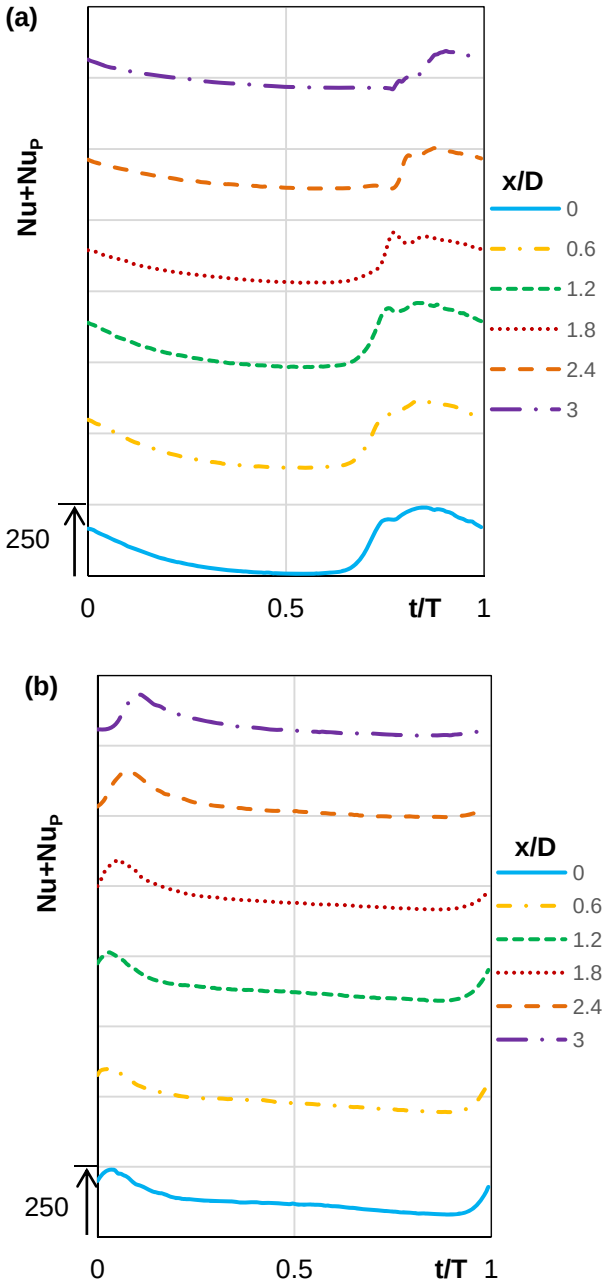


Fig. 7 Nusselt number dependence on the different instances in the period: (a) z/D = 1, (b) z/D = 5; *P* = 3W.

Comparison of the results obtained experimentally (shown in Fig. 6) with results from CFD (shown in Fig. 11) shows very good agreement of the phase averaged velocity magnitude profiles in the distance of *z*/*D* from 0 to 3. In the distance of *z*/*D* from 3 to 5 the velocity profiles obtained from CFD are significantly affected by the presence of the wall. This effect is not consistent with the experimental results because that were measured in the free space (without the wall).

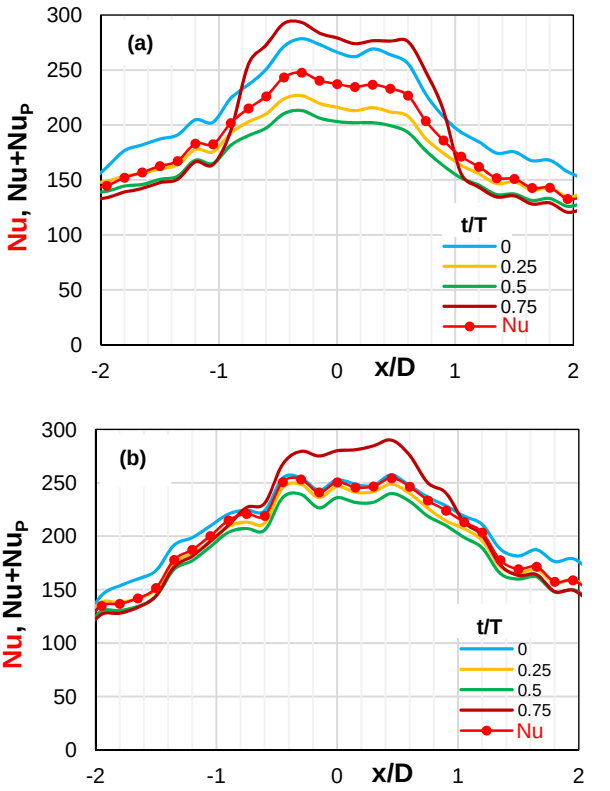


Fig. 8 Distribution of the phase-averaged (Nu+Nu$_P$) and time-mean Nusselt (Nu) number; (a) *z*/*D* = 1, (b) *z*/*D* = 5; *P* = 3W.

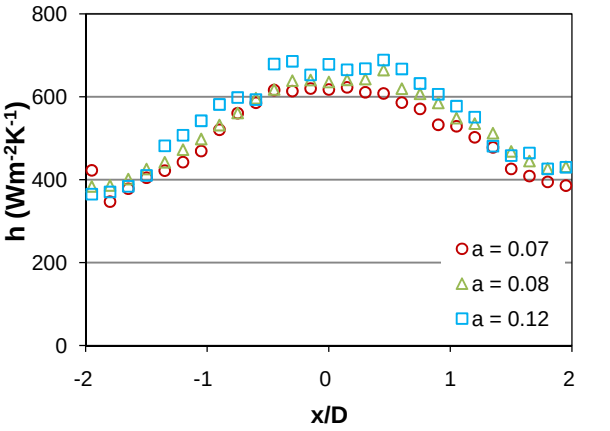


Fig. 9 Heat transfer coefficient (time-mean values) measured with set overheat temperatures of 20.83°C, 23.81°C, and 35.71°C; measured in distance *z*/*D* = 5; *P* = 3W.

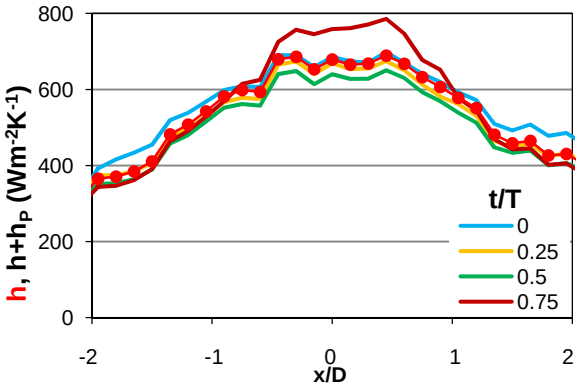


Fig. 10 Heat transfer coefficient (phased averaged) with overheat of 35.71°C; measured in distance *z*/*D* = 5; *P* = 3W.

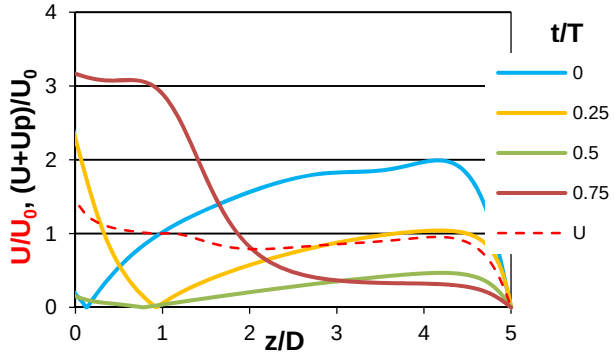


Fig. 11 Dependence of the phase-averaged velocity magnitude at different instances in the period and the time-mean velocity on the distance from the actuator orifice; CFD results.

5. Conclusions

This paper brings results of the synthetic jet experiments focused on the measurement of unsteady heat transfer coefficient by the glue-on thermoanemometry probe. As a first step, the working frequency of the SJ actuator was found as 74 Hz. On this frequency all experiments were carried out. From the velocity measurement, the time-mean orifice velocity U_0 and Reynolds number Re_{SJ} are determined as 7.12 m/s, and 4563, respectively. Heat transfer experiments were performed in the constant temperature mode of the thermoanemometer for three overheat ratios (a = 0.07, 0.08, and 0.12), the over temperature was then set as 20.83°C, 23.81°C, and 35.71°C, respectively. According to the overheat ratios, the plate was heated to the temperature of (43, 46, and 58)°C. Based on the thermoanemometer setting, i.e., setting of the whole system, probe and Wheatston's bridge resistances, the average and instantaneous values of Nusselt number and heat transfer coefficient were evaluated.

Experimental results of the SJ actuator working frequency and the velocity measured in the orifice output area were used for the development of the CFD solver based on the OpenFOAM platform. The experimental results of velocity profiles were used for the validation of the new-developed solver. After that the developed solver could be used with quite good accordance for solving the impinging synthetic jet. The first goal of the future work is to create a methodology to evaluate the heat transfer coefficient. The second one is the validation of the CFD solver to simulate heat transfer, especially in the near wall region. Then the experimental results shown in this paper will be used.

Acknowledgements

We gratefully acknowledge the support of the Grant Agency of the Czech Republic (Project No. 16-16596S) and the project SGS 21135 (Ministry of Education, Youth and Sports of the Czech Republic).

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Modern Environmental Science and Engineering (ISSN 2333-2581)
September 2017, Volume 3, No. 9, pp. 653-660
Doi: 10.15341/mese(2333-2581)/09.03.2017/006
Academic Star Publishing Company, 2017
www.academicstar.us

Afforestation with the Purpose of Restoring the Protected Natural Area "Cerro del Punhuato", Morelia, Michoacán

Marcial Reyes Cázarez
Patzcuaro Institute of Technology, Mexico

Abstract: During the last decade in the State of Michoacán Mexico, green spaces, recreation areas and the quality of the environment have been lost due to anthropogenic activities, which have impacted the sustainability in the forestry sector. This proposal was established in the Protected Natural Area of Cerro del "Punhuato", in the municipality of Morelia, Michoacán, Mexico, in the period 2009-2010 an essay that studies the establishment of a plantation of ***Pinus michoacana Martínez***, in four treatments, health and soil temperature. The plantation was carried out in an area of one hectare, divided in four treatments in a quarter of a hectare per treatment. Subsequently, an analysis was carried out by species between ***Pinus pseudostrobus lind***. ***Pseudostrobus*** and ***Pinus michoacana Martinez*** throughout the plantation. Survival rate, health and soil temperature were analized as key factors for the establishment of the plantation. Significant differences were found between the variables studied. In the established plantation pest attacks were found by defoliating insects and sap-sucking insects, where a sanitary siege was established by using a slightly toxic emulsifier insecticide. The analysis of the survival rate, health and soil temperature showed significant differences among the different species, where the species of ***Pinus michoacana Martinez*** adapted better to the conditions and highlights that the analysis of soil temperature was a determinant factor in the establishment of the plantation. This analysis is fundamental in the development of restoration of area due to the failed forestation attempts where society shows interest in the recovery of green spaces through the active participation of academic groups, educational institutions, civil society organizations and society.

Key words: afforestation, restoration, survival

1. Introduction

At the global level the main objective is the conservation and preservation of natural resources since the different types of vegetation that exist in the world are of vital importance for the development of the human race, because of this, new projects and strategies are proposed every day for the restoration of soil, by means of forestation and reforestation in some areas that have been designated for the establishment, regeneration or production of native vegetation and/or representative of the areas in which they are found, such is the case of the Cerro del Punhuato.

To date, the calculations of restoration through forestation and reforestation, as well as the loss of forest area in Mexico have been subjective and lack a statistical base.

In these conditions it's necessary to urgently implement, effective and efficient actions to increase the forest area and attempt to protect the soil, the harvesting of rainwater and maintain the diversity of climates, to increase soil fertility and productivity as rector of the conservation and restoration of ecosystems.

Finally, reforestation and afforestation is the option to recover degraded areas through actions such as

Corresponding author: Marcial Reyes Cázarez, Master of Sciences and Wood Technology, research areas/interests: management to natural resources and research on community-based. E-mail: mreyes@itspa.edu.mx.

watershed protection and restoration for the subsistence of the species, as well as the conservation and preservation of the natural protected areas [8].

Based on the above information in the protected natural area known as "Cerro del Punhuato", municipality of Morelia, where we find a high degree of ecological disturbance, no presence of soil and little vegetation, an afforestation was carried out for the purpose of restoring the area with favourable species such as *Pinus michoacana* and *Pinus pseudostrobus* since both, adhere to the environmental requirements of the surrounding environment, the aim was to increase the vegetation area, the reduction of soil erosion, the generation of soil and increased uptake of water, offering new alternatives for planting in order to know which factors have a significant influence on its successful establishment, and in this way achieve a greater survival of the plant and increase the forest area in the site, being a strategic space for the generation of environmental services that directly benefit the society, scientific activities and the environment [12].

There are various techniques that can be used to promote ecological restoration and the interaction with the participation of society to hopefully establish parameters to increase survival of the plantations and increase the interest of the people. This research proposes the following:

Planting trees to increase the forest area in the "Cerro del Punhuato" will encourage citizens to participate in order to generate greater interest from society in the environment and actions that benefit the increase of vegetation area. In environmental issues, it's suggested that as a result of greater vegetation, soil loss will be reduced and gradual regeneration of soil will begin. The regeneration of soil and increase of vegetation will increase rainwater harvesting [5].

2. Objective

Perform an experimental plantation to restore a Protected Natural Area with two species of pine, to determine which is the best in terms of health and survival rate in the "Cerro del Punhuato", Morelia, Michoacán.

3. Material and Methods

In Morelia, Michoacán, Mexico, a trial of two species of the genus *Pinus*, in the Protected Natural Area known as "Cerro del Punhuato", an Ecological Preservation Area, which has a program of management and is under the supervision and care of the government of the state of Michoacán, Mexico, to whom a petition was requested in order to carry out the research.

The experimental site is located in an area of 01-00-00 has. or 10.000 m² of land, in which there are herbaceous and shrub species, some trees, as shown in, the latter introduced or exotic species, which present some shortcomings.

The site has an approximate slope of between 77° and 41°, there is abundant presence of stones, exposed soil and low permeability to the subsoil.

Later the experimental site was divided in four treatments or plots which were classified as follows (Fig. 2), plot 1 has a steep slope between 73° and57° and there is a high degree of disturbance; Plot 2 The slope is soft and ranges from 56° to 41° with a high degree of disturbance; plot 3 has a steep slope between 77° and 50° Low Disturbance; plot 4 has a gentle slope of 47° to 42° and low disturbance (Table 1).

In (Fig. 3), we observe the distribution of the plantation, where the squares represent trees of

Fig. 1 Experimental site for carrying out afforestation.

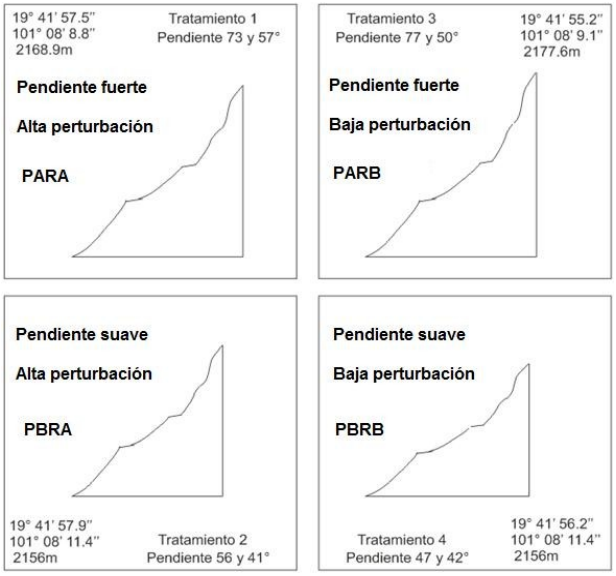

Fig. 2 Outline of the delimitation of the plots and experimental treatments, as well as the slope representative and nomenclature of each of the treatments.

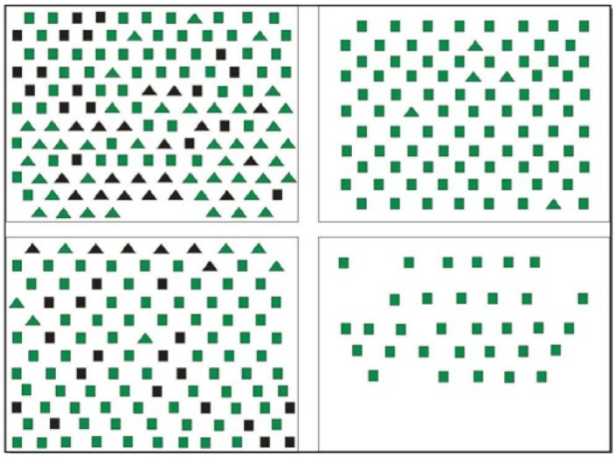

Fig. 3 Distribution scheme for the stablishment of the plantation by treatment.

Table 1 Characteristics of the slope, soil conditions, degree of disturbance and nomenclature of treatment.

Site	Degree Slope	Disturbance	Nomenclature
Plot 1	(73° to 57°) Steep	High	PARA
Plot 2	(56° to 41°) Soft	High	PBRA
Plot 3	(77° to 50°) Steep	Low	PARB
Plot 4	(47° to 42°) Soft	Low	PBRB

Pinus michoacana and triangles represent trees of *Pinus pseudostrobus* [7].

The first species considered for this plantation, is the *Pinus michoacana Martinez*. Also known as Lazio pine. A native of Mexico and with a geographical distribution of the 16°35' and 21°15' north latitude and 92°15' and 102°05' West longitude. As a particular feature it establishes in slopes of pine forests and Encino Oak Tree forests [6].

The other species that account with the necessary requirements to be able to settle on the site is the *Pinus pseudostrobus Lindl*. var. *pseudostrobus*, commonly known in the state of Michoacán as ortiguillo pine or white pine, native to Mexico, Honduras and Guatemala, which is distributed geographically between the 17°15' and 29°15' north latitude and 92°05' and 108°35' West longitude, frequently found in pine forests and pine-oak forests, however it cannot be ruled out its use in restoration of degraded soils [7].

Table 2 Summary of the main historical climate factors in the site.

Climate data						
Average temperature (°C)	2003	2004	2005	2006	2007	2008
	19	18.4	19.1	18.9	18.3	18.8
Relative humidity (%)	59	62	58	56.4	54	56.1
Total insolation (hrs)	1834.6	1699.4	1867	1732.6	1697.1	1667.1
Evaporation total (mm)	2657.56	2634.44	2886.31	2625.09	2713.56	2801.5
Total Rain (mm)	1007.7	1073.7	843.5	923.1	725.5	616.9

Fig. 4 *Pinus michoacana Mart.* specimen, healthy.

Fig. 5 ***Pinus pseudostrobus*Lindl.specimen, healthy.**

The development of the strains was carried out with 40 cm. in length, width and depth, (Fig. 6) in the experimental site.

The plantation was carried out in the month of September 2009, (since this year was atypical in its rainy season) according to the physiography of the ground and respecting the existing vegetation with a distribution of, 3 meters apart, the final distribution.

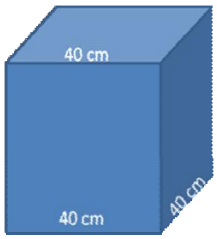

Fig. 6 Strain scheme.

Table 3 Species established in the plots, by species and proportion.

Treatment	Species	# of established species	Ratio %
Plot 1	*P.michoacana*	74	55
	P.pseudostrobus	59	45
Plot 2	*P.michoacana*	89	83
	P.pseudostrobus	18	17
Plot 3	*P. michoacana*	83	95
	P.pseudostrobus	5	5
Plot 4	*P. michoacana*	32	100
	P.pseudostrobus	0	0

Then and given the inequality of specimens per species in each of the treatments we proceeded to perform a random analysis (with the SAS software), to select 32 individuals per plot of *Pinus michoacana*, then a new random analysis was carried out to choose 74 individuals of *Pinus michoacana* to evaluate the general level in the plantation *Pinus pseudostrobus*.

For six months, the evaluations were performed every 45 days, counting the survival rate and monitoring the health [2] of each species.

The general analysis used in the case of *Pinus michoacana* is the following:

$$Yij = \mu + Pi + PRijRj + + Eij$$

While in the case of analysis by species (*Pinus michoacana vs Pinus pseudostrobus*) is the following:

$$Yij = \mu + If + Eij$$

Statistical analysis consisted of analysis of variance (ANOVA) and a comparison of means using the Tukey test, carried out with the variables of soil temperature, health and slope since they are regarded as variation factors that may affect the survival of the trees. For ANOVA the GLM procedure was used (general linear model), as well as the The Tukey test for average statistical analysis of comparison of the SAS statistical package [13].

Subsequently a hypothesis test was done using an F-Snedecor test. As shown below:

Hypothesis testing.

Ho = T1 = T2 = T3 = T4 VS has = T1 ≠ T2 ≠ T3 ≠ T4

Decision Rule:

If F calculated > F tabulated

Reject Ho. otherwise accept.

Word, Access and Excel from the Microsoft Office package were used for the handling and processing of data.

The (Fig. 7), shows the amount of living and dead trees for each of the species chronologically, according to the months in which assessments were carried out.

In the analysis of variance for the survival rate significant differences were found with regard to disturbance (D = 0.0003), where we found that the sites

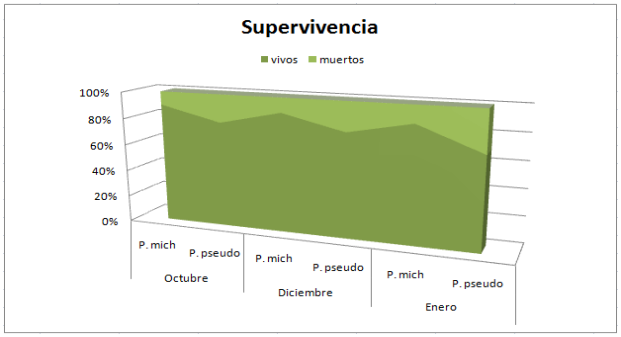

Fig. 7 Chronological graph of plantation survival.

Table 4 Variable survival analysis of *Pinus michoacana* in treatments.

Fuente de variacion	Grados de libertad	Suma de cuadrados	Cuadrado medio	F	P
Pendiente	1	0.000	0.000	0.00	1.0000
Perturbacion	1	1.531	1.531	0.00	<0.0001
Pendiente* perturbacion	1	0.000	0.000	0.00	1.0000
Error	124	13.937	0.112		

with high degree of disturbance had the highest mortality rate, unlike sites with a lower degree of disturbance where mortality rate was lower. The slope had no inference in survival because it does not show significant differences.

The following results were obtained from the tests:

Table 5 Hypothesis test for the variable survival of *Pinus michoacana* in treatments.

Fuente de variacion	Grados de libertad	Suma de cuadrados	Cuadrado medio	F	P
Pendiente	1	0.000	0.000	0.00	1.0000
Perturbacion	1	1.531	1.531	13.62	0.0003
Pendiente* perturbacion	1	0.000	0.000	0.00	1.0000
Error	124	13.937	0.112		

In the hypothesis test we note that the disturbance is a significant factor in the survival rate (P = <.0001), we can observe that the slope and the interaction of the slope and the disturbance does not show significant differences in survival rate.

There are significant differences for the variable health in disturbance (P = 0.0031,), since the greater the degree of disturbance on the site, the greater the number of dead specimens, while the lower the degree of disturbance, the less number of specimens attacked by pests. The effect of the slope is not significant as it doesn't show differences, while the effect of the slope and disturbance show significant differences (P = 0.0101).

In the hypothesis test for health we note that the effect of the slope (P = 0.8556) and the effect of disturbance (P = 0.4546) show no significant differences, but not in the case of the interaction between the slope and the disturbance (P = 0.0101).

In Fig. 8, we can see that there are no significant differences in survival rate and health. In the case of soil temperature there are significant differences with regards to the slope because the temperature of soil on the gentle slopes (A) is where *P.michoacana* establishes better, while steep slopes (B) are a limiting factor for the temperature on the establishment of *P.pseudostrobus.*

In Fig. 9, we can see that for the variable survival rate, there are significant differences between sites with high degree of disturbance (B) and sites with low degree of disturbance (A), where the sites with a low

Table 6 Analysis of variance for the variable health of *Pinus michoacana* in treatments.

Fuente de variacion	Grados de libertad	Suma de cuadrados	Cuadrado medio	F	P
Pendiente	1	0.070	0.070	0.36	0.5475
Perturbacion	1	1.757	1.757	9.09	0.0031
Pendiente* perturbacion	1	1.320	1.320	6.83	0.0101
Error	124	23.968	0.193		

Table 7 Hypothesis test for the variable health of *Pinus michoacana* in treatments.

Fuente de variacion	Grados de libertad	Suma de cuadrados	Cuadrado medio	F	P
Pendiente	1	0.070	0.070	0.05	0.8556
Perturbacion	1	1.757	1.757	1.33	0.4546
Pendiente* perturbacion	1	1.320	1.320	6.83	0.0101
Error	124	23.968	0.193		

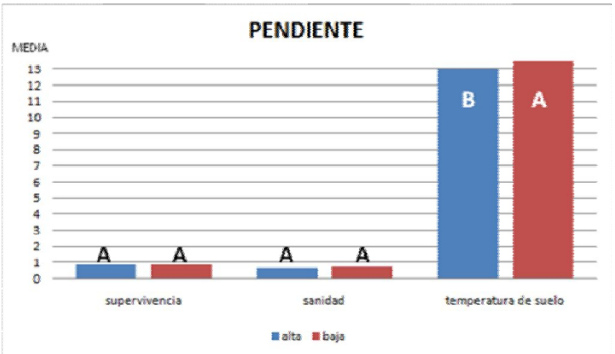

Fig. 8 The Tukey test (α = 0.05) for the effect of the slope, in the variables of survival, health and soil temperature for the establishment of *P. michoacana*.

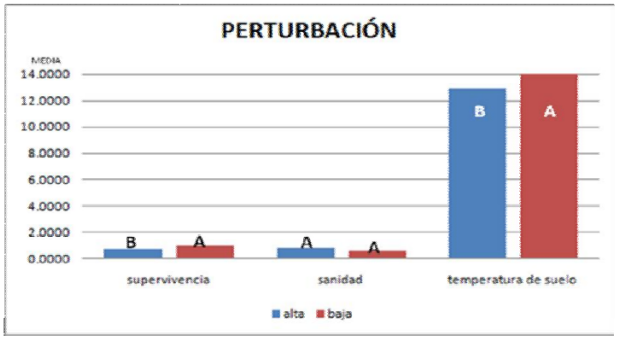

Fig. 9 The Tukey test (α = 0.05) for the effect of the disturbance, in the variables of survival rate, health and soil temperature for the establishment of *P. michoacana.*

degree of disturbance is where there's a lower incidence of mortality of *P.michoacana*. For the health variable we note that there are no significant differences. In the case of soil temperature there are significant differences in the effect of the disturbance because the temperature of soil in sites with little disturbance (A) is where *P.michoacana* settles better, and the sites with high disturbance (B) are a limiting factor for the effect of temperature on the establishment of *P.pseudostrobus.*

In Fig. 10 we can see the effect of the treatments in the variable survival rate, there are significant differences between the treatments PARA, PBRA, (B) and PBRB, PARB, (A), respectively. With regard to the health variable PARA, PBRA, (A) and PARB, PBRB (B), there are significant differences between these as well. For soil temperature the treatment PARA (c) shows significant differences, compared to the other three treatments, while the PBRA and PARB treatments (B), don't show significant differences between them but it does show significant differences with the other two treatments and treatment PBRB (A), there are significant differences with the other three treatments, where the treatment with a gentle slope and low disturbance in which *P. michoacana* plant settles best.

The obtained results by species, consist in the assessment of *Pinus michoacana* and *Pinus pseudostrobus* in the plantation which evaluates the establishment of both species

In the variance analysis significant differences were found in survival rate in the establishment of both species (P = 0.0037). *Pinus michoacana* had the greatest survival rate.

In the case of the health variable, in the variance analysis, we found significant differences (P = 0.0486), in which the species with the least number of individuals with pest attack was *Pinus michoacana*.

In the variance analysis for the variable soil temperature, we found that there are significant differences (P = 0.4781).

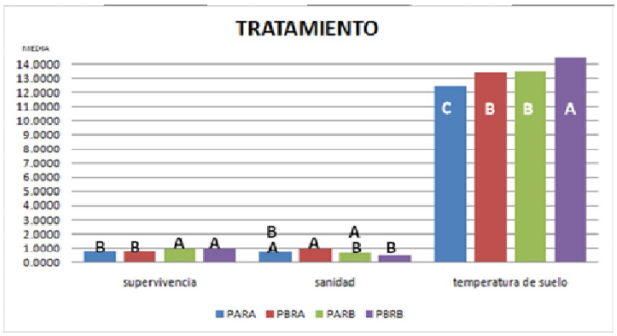

Fig. 10 The Tukey test (α = 0.05) for the effect of the treatment, in the variables of survival rate, health and soil temperature for the establishment of *P.Michoacana.*

Table 8 Variance analysis for the variable survival rate for the assessment of the establishment of *Pinus michoacana* and *Pinus pseudostrobus* in the plantation.

Fuente de variacion	Grados de libertad	Suma de cuadrados	Cuadrado medio	F	P
Especie	1	1.461	1.461	8.68	0.0037
Error	152	25.584	0.168		
Total	153	27.054			

Table 9 Variance Analysis to evaluate health in the establishment of *Pinus michoacana* and *Pinus pseudostrobus* in the plantation.

Fuente de variacion	Grados de libertad	Suma de cuadrados	Cuadrado medio	F	P
Especie	1	0.785	0.785	3.95	0.0486
Error	152	30.207	0.198		
Total	153	30.993			

Table 10 Variance analysis for the variable soil temperature for the assessment of the establishment of *Pinus michoacana* and *Pinus pseudostrobus* in the plantation.

Fuente de variacion	Grados de libertad	Suma de cuadrados	Cuadrado medio	F	P
Especie	1	1.272	1.272	0.51	0.4781
Error	152	382.517	2.516		
Total	153	383.790			

Subsequently a comparison analysis of the averages using the Turkey test found the following:

As we can see in the variable survival rate doesn't show significant differences between the species being *P. michoacana* the one that established better.

With the above findings of the reforestation, it's considered that the plantation has a high level of survival rate in spite of the steep slope that exists on the site, as well as high disturbance, whereas in a trial of *Pinus ponderosa* in a level plane and hillside site, where the survival rate was 3% on the level plane, while in the slopes the survival rate was higher [14].

In the case of the plantation in the Cerro del Punhuato the plants had no limitations during its establishment or by the altitudinal gradient, nor by the lack of soil in the upper parts of the slope of the hill

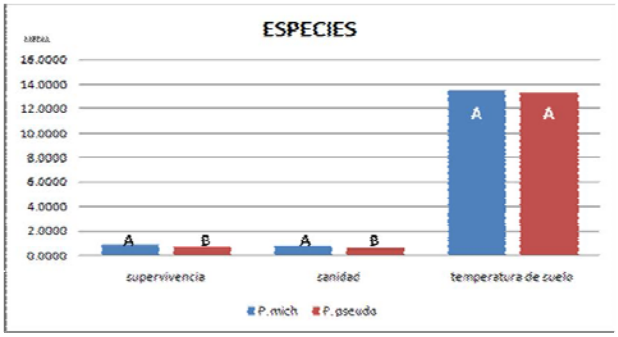

Fig. 11 The Tukey test ($\alpha = 0.05$) for the evaluation of the species, with the variables survival rate, health and soil temperature.

where the slope was steep and pronounced, contrary to reports [9], to examine the potential establishment of three species of the Cloud Forest *Fraxinus uhdeii lusitana*, *Magnolia* and *Quercus Salicifiolia*, under the canopy of *Pinus douglasiana*, where the different trends in mortality of seedlings, suggest that the survival in the top of the hillside is more limited due to the limited availability of water and light, not by the condition or nutrients of the soil.

From the results we can take that since slopes are less exposed to the sun there are lower temperatures [11], which is the case in the plantation in Cerro del Punhuato where the soil temperature where *Pinus michoacana* and *Pinus pseudostrobus* were planted showed significant differences, depending directly on the factors of the slope and the disturbance of the site [10].

In the analysis of the studied plants by species we found that the main limiting factor is the existing disturbance in the sites, where due to the conditions microorganisms survive long periods. The species that established the best was *Pinus michoacana* since it had the lowest mortality rate, as well as the lesser number of individuals attacked by insects, while *Pinus pseudostrobus* presented the lower survival rate and greater number of individuals with insect attacks. That *Pinus pseudostrobus* planted under good conditions presented a high rate of growth.

5. Conclusion

The survival rate depends directly on the degree of disturbance on the site, the greater the degree of disturbance the lower the survival rate, while the lower the degree of disturbance the greater the survival rate. [3]

The health of the species for its part will depend on the degree of disturbance as well as the climatic conditions of the site since both species require specific environmental conditions to be able to develop, such as soil and environmental moisture, where greater

amounts of disturbance exist is also where insects establish and develop better.

Soil temperature is a factor that depends entirely on the degree of the slope, as well as the degree of disturbance in the site where the plant is set, since soil temperature will depend on the exposure of the plant.

With respect to the different degrees of slope, the two species can adapt to the different degrees of slope and can establish without risking the development of both species. [4]

The species with the highest survival rate is *P. michoacana*; which also showed a lesser number of specimens attacked by insects.

For its part, the *P. pseudostrobus* had a lower survival rate in the treatments, it also had the highest number of specimens attacked by insects.

The effect of the slope is not a limiting factor for the establishment of the species, however it depends on the temperature of the treatments because sun exposure is variable depending on the degree of inclination it presents.

For future reforestation projects in the Natural Protected Area "Cerro del Punhuato" we recommend establishing *P. michoacana* because of its greater survival rate.

The size and the age of the plant of *Pinus michoacana* is an essential factor for future research. When it exceeds 15 cm high, considering that it is a tufted plant it must be planted in containers with sufficient amounts of substrate for its establishment in the forest, ideally the container should have a capacity of 5000 cm^3, or 5 lts.

It is necessary to perform a health inspection, where the phytosanitary conditions of The Natural Area will be determined.

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Modern Environmental Science and Engineering (ISSN 2333-2581)
September 2017, Volume 3, No. 9, pp. 661-666
Doi: 10.15341/mese(2333-2581)/09.03.2017/007
Academic Star Publishing Company, 2017
www.academicstar.us

Weed Vegetation around Red Dragon Fruit Plants: *Hylocereus polyrhizus*

Retno P. Sancayaningsih, Wilhelmus T. A. Sanjaya, W. Supriyanto, Ilham M. Laksono, and Devi A. Shara
Faculty of Biology, Universitas Gadjah Mada, Indonesia

Abstract: Increasing red dragon fruit productivity faces management weed problem. This study aims to investigate the structure and composition of weeds around dragon fruit plants, the presence of each growth form and dominant weed species, the similarity index between weeds of dragon fruit plants and other crops, and the physicochemical conditions at Sabila Farm in Yogyakarta. The total farm area of each crop was divided into 50 square-shaped areas using a gridline, so all of the areas have the same size. The size of these areas was adjusted in accordance with the total area of the studied plants. Subsequently, a 1m x 1m plot was put in each of 15 areas chosen randomly from the 50 areas. The structure and composition of weed vegetation in the dragon fruit farm responded to soil condition, rooting systems and psychochemical condition of dragon fruit plants. The formation of the structure and composition of the weed vegetation could be attributed to a possible reciprocal relation from the interaction patterns between the weeds and the dragon fruit plants. Red dragon fruit's weed vegetation was specific and was influenced by interaction patterns that could be formed between the weed communities and the fruit crops.

Key words: weed, vegetation, red dragon fruit, ecology, ecosystem

1. Introduction

The need for dragon fruit in Indonesia is getting higher, triggering the increasing number of dragon fruit farms. As a relatively new commodity in Indonesia, dragon fruit has been very popular among people because it has a high economic value and rich in health-related benefits.

Although dragon fruit plants have great potential and are being developed in Indonesia. Its domestic production is often constrained. The growth of the farms in Indonesia is not significant enough to increase the production of the fruit in the country. This is because dragon fruit plants are often attacked by pests or diseases. Although various preventive measures have been done to control them, these cannot stop the spread of the diseases and pests. An important factor that causes less effective prevention of these problems is weed control technique that is less suited to soil condition and the structure of floor vegetation. To carry out a proper weed control techniques it is necessary to know in advance the composition and structure of weed vegetation in a dragon fruit farm area [1]. This is in accordance with Winarsih (2007) [2], who states that in addition to pests and diseases, the growth of weeds can cause the emergence of the diseases and pests for fruit crops.

Weeds that are able to live in farm areas are likely to interact with the fruit crops. Therefore, it is certain that each fruit has weed vegetation with different compositions and structures. In this study, srikaya fruit was used as the comparison for dragon fruit. Both fruits were in the same farm, Sabila Farm.

This study aims to investigate the structure and composition of weeds around dragon fruit plants, the presence of each growth form and dominant weed species, the similarity index between weeds of dragon

Corresponding author: Wilhelmus T. A. Sanjaya, Bachelor; research areas/interests: environmental microbiology, ecology, food microbiology. E-mail: terangarga@gmail.com.

fruit plants and other crops, and the physicochemical conditions at Sabila Farm in Yogyakarta.

2. Material and Methods

This research was conducted from August 4 to 18, 2015 at Sabila Farm located on Kaliurang Street km 19.5, Sleman Regency, Special Region of Yogyakarta. Geographically, Sabila Farm is located at the foot of Mount Merapi with an altitude of about 500-550 meters above sea level. Rainfall in the area is between 3000 and 4488 mm per year. The average temperature throughout the year is 26.5°C. The research site is a 5 ha dragon fruit farm with a spacing of 3 m × 3 m or 2.5 m × 2.5 m. Sabila Farm lies on the coordinates of S7O39'12.5532 "E110O25'27.5988". The total farm area of each crop was divided into 50 square-shaped areas using a gridline, so all of the areas have the same size. The size of these areas was adjusted in accordance with the total area of the studied plants. Subsequently, a 1 m × 1 m plot was put in each of 15 areas chosen randomly from the 50 areas. The tools used in this research were the plot (1 m × 1 m), places for dry herbaria, pH meter, soil tester, and lux meter.

A total of 30 plots made of ropes and stakes were placed randomly, but only 15 of them were put in the 15 selected areas. In each plot, weed species were identified, and the members of each species were counted. Unidentified weeds were made herbariums and identified by consulting the book of "A Field Guide: Tropical Plant of Asia" [3]. Subsequently, the data were analyzed to obtain density, relative density, frequency, relative frequency, and important value. Physicochemical parameters of the environment in each plot (sampling spot) including soil moisture, soil acidity, and light intensity were measured using soil tester, pH meter, and lux meter.

After all parameters were obtained, the data were analyzed. These included density, frequency, relative frequency, relative density, importance value, and similarity index between dragon fruit tree weeds and other plant weeds in the farm.

The data for the analyses on the weeds structure are density and frequency. Subsequently, relative density and relative frequency were calculated [4]. The next step was comparing the structure and diversity of weeds around the plants of the red dragon fruit and srikaya fruit by using Sorensen Similarity Index (IS). The following is the formula.

Density of species A : $\frac{\text{Individual calculation of species A}}{\text{Volume of water sample (l)}}$

Relative Density : $\frac{\text{Individual Density of species A}}{\text{Total of community density}} \times 100\%$

Frequency : $\frac{\text{Presence of species A in each sampling spot}}{\text{Total of sampling spots per location}}$

Relative Frequency : $\frac{\text{Individual Frequency of species A}}{\text{Total of community frequency}} \times 100\%$

Important Value : Relative Density + Relative Frequency

(Wetzel and Likens, 1991) [5]

Similarity Index: $$IS = \frac{2C}{A+B}$$

The value of Sorensen Similarity Index (IS) is obtained from multiplying C value by 2 or the smallest quantitative value of a species in two compared sites divided by the sum of the total quantitative values of the first plant (A) and the total quantitative value of the second plant (B).

3. Results and Discussion

3.1 The Composition and Structure of Weed Vegetation around Dragon Fruit Plants

Based on the analysis results of weed vegetation in the area of red dragon fruit plant SF 1, there were 1401 individuals, 14 families, 26 genera, and 31 species. In addition, there are 2 families with 9 species of grass category, 7 families with 11 species of herbaceous category, and 9 families with 11 species of shrub category. The dominant family was the *Asteraceae* family consisting of 6 species. Other families with significant number included *Rubiaceae* with 3 species and *Cleomaceae* with 1 species (Table 1).

Table 1 Composition and structure of weed vegetation in dragon fruit garden Sabila farm.

Growthform	Famili	Number of Spesies	relative density (%)	relative frecuency (%)	Important value (%)
Grass					
Poaceae	*Agrotis gigantean*	1	0.07	0.72	0.79
	Axonopus compressus	1	0.07	0.72	0.79
	Cynodon dactylon	1	0.07	0.72	0.79
	Digitaria setigera	1	0.07	0.72	0.79
	Echinochloa colonum	4	0.29	0.72	1.01
	Eleusine indica	3	0.21	1.44	1.65
	Paspalum conjugatum	16	1.14	2.88	4.02
Cyperaceae	*Cyperus kyllingia*	5	0.36	2.16	2.52
	Cyperus rotundus	11	0.79	3.6	4.39
Herbs					
Amaranthaceae	*Amarantus luvidus*	14	1	1.44	2.44
	Amarantus sp.	40	2.86	3.6	6.46
Asteraceae	*Eclipta prostrate*	5	0.36	1.44	1.8
	Crassocephalum crepidiodes	6	0.43	2.88	3.31
	Ageratum conyzoides	135	9.64	5.04	14.68
Rubiaceae	*Borreria repens*	1	0.07	0.72	0.79
	Borreria alata	27	1.93	5.76	7.69
Piperaceae	*Peperomia pellucida*	6	0.43	0.72	1.15
Convolvulaceae	*Dichondra repens*	113	8.07	7.91	15.98
Euphorbiaceae	*Euphorbia hirta*	18	1.28	7.19	8.47
Portulacaceae	*Portulaca oleracea*	13	0.93	0.72	1.65
Shrub					
Oxalidaceae	*Oxalis barrelieri*	3	0.21	1.44	1.65
	Oxalis corniculata	12	0.86	3.6	4.46
Phyllanthaceae	*Phyllantus niruri*	59	4.21	10.07	14.28
	Phyllantus sp.	2	0.14	0.72	0.86
Asteraceae	*Emilia soncifolia*	3	0.21	2.16	2.37
	Galinsoga parviflora	335	23.91	6.47	30.38
	Acmella panicullata	1	0.07	0.72	0.79
Rubiaceae	*Hedyotis corymbosa*	172	0.86	3.6	4.46
Plantaginaceae	*Scopana dulcis*	182	12.99	5.04	18.03
Onagraceae	*Ludwigia hyssopifolia*	1	0.07	0.72	0.79
Cleomaceae	*Cleome rutidosperma*	210	14.99	10.07	25.06

Weed vegetation in the dragon fruit farm was dominated by shrubs and herbs, while grass weeds were relatively fewer. The shrubs were dominant as they have high competitiveness and survival capacity in dry or slightly shaded soil. In addition, their structure is more resistant when living side by side with dragon fruit with a root system that can squeeze the surrounding weeds. Moreover, *Asteraceae* rejects insects, so this plant has great potential to be bio-insecticides and a multipurpose drug [6].

The most common weed species that were found were *Galinsoga parviflora*. This weed is one of the most common members of *Asteraceae* found in fertile land. This plant is able to live in hot areas even with minimum shade. *Galinsoga parviflora* has a strong capability to absorb water, but this species can only thrive on very fertile land but not on dry land.

Therefore, this species can be used as an indicator of soil quality. This plant has the ability to grow faster to compete with other small plants. Its ability to complete his life cycle in a short time can make this plant abundant on a farm land. This species is not harmful to the farm crops. On the other hand, *Galinsoga parviflora* in fact has potential as a plant that has antibacterial and antifungal activity [7]. In addition, the existence of weeds *Amaranthus* sp. and *Galinsoga parviflora* Cav. in the farm invites Arthropod predators that can prey on plant pests [6].

Meanwhile, some grass species such as *Agrotis gigantean, Axonopus compressus, Cynodon dactylon,* and *Digitaria setigera* had the smallest number with only one plant for each species. This was because grass plants are difficult to grow in the red dragon fruit farm. Grass growth was hampered by the root structure of dragon fruit plants that does not allow the grass to grow. This root structure makes it difficult for the grass' fibrous roots to function well. Furthermore, the root structure of dragon fruit plants makes the soil texture relatively harder.

In addition, weeds that can cause considerable losses, such as *Axonopus compressus, Boreria* sp., *Cynodon dactylon, Cyperus* sp., *Echinochloa colonum, Eleusine indica,* and *Paspalum conjugatum,* were also found. These weed species have considerable negative effect on farm crops because in addition to being the ancestors of pests and diseases, their population growth will absorb many of the nutrients contained in the soil. Furthermore, the researchers also found some weeds that are not too dangerous for the dragon fruit plants, but they still have to be controlled. These weeds were *Ageratum conyzoides, Cyrtococcum* sp., and *Digitaria* sp.

The results of data analysis on weed vegetation structure in area Sabila Farm 1 (SF 1) at the dragon fruit farm, Sabila Farm, are shown in Table 1 that present important value of each weed. For grass weeds, the highest important value (4.38%) belonged to *Cyperus rotundus*. In addition, *Paspalum conjugatum* had an important value of 4.02%. These show that *Cyperus rotundus* and *Paspalum conjugatum* were the most dominant among other types of grasses. For herbaceous weeds, the highest important value (15.98%) belonged to *Dichondra repens* followed by *Ageratum conyzoides* with an important value of 14.67%. For shrub weeds, the highest important value (30.39%) belonged to *Galinsoga parviflora*. It is an annual herb found in most temperate and subtropical regions of the world as a weed of many crops and waste land. *Galinsoga parviflora* is highly competitive and quickly spreads and becomes dominant in a field. A study by Rai and Tripathi (1984) [8] indicated that at higher altitude, that weed was more successful as indicated by its higher population density, longer life of its first and second cohorts and greater biomass production in crop fields. Seedling recruitment and survivorship of cohorts were significantly influenced by mode of cultivation, crop type and altitude. The growth of the weed was affected by altitude and crop type as indicated by its poor performance in radish field at lower altitude than at higher altitude [9]. *G. parviflora* can be invasive species which invade agricultural and other disturbed areas in most temperate and subtropical regions of the world [10]. In addition, there are several species of shrub weeds that had high important values, among which are *Cleome rutidosperma* (25.06%), *Hedyotes corymbosa* (20.19%), and *Scoparia dulcis* (18.03%) (Table 1). This proved that shrub weeds were very dominant in area SF1. This was because shrub weeds had relatively stronger roots than grass and herb weeds. Root system became very important for them to grow on the dragon fruit farm because the root structure of dragon fruit plants was strong and could reach a relatively wide area around the plants, so it can suppress weed populations with weak root systems. Red Dragon Fruit have an extensive root system. That condition makes other plants around the red dragon fruit stressed [11]. In addition, Sabila Farm (SF 1) is placed in Merapi mountain area. Generally, Mountain clusters that

inhabit the newly arable land are characterized by the highest disturbance level, soil compactness level, total natural species, and total shrubs, but the lowest number of weeds and species diversity and evenness [12].

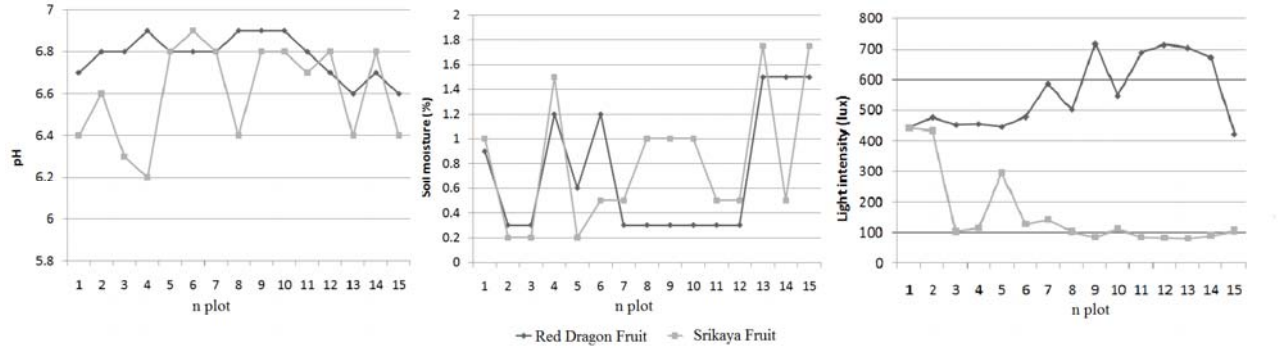

Fig. 1 Environmental condition in red dragon fruit area and Srikaya fruit area: (a) soil pH, (b) soil moisture, and (c) light intensity.

3.2 Similarity Index and Physicochemical Condition

Sorensen similarity index was obtained through the comparison between weed vegetation around the dragon fruit plants and srikaya fruit trees. Weeds around srikaya trees were selected in the calculation of the similarity index because srikaya trees had a different structure as they had a relatively larger shade than that of dragon fruit plants. In srikaya farms weeds that relatively enjoy sun exposure respond to this condition.

The result of the calculation of the similarity index was 36.41%, so it can be said that the structure of weed vegetation in the dragon fruit farm and the srikaya farm was very different. The similarity index in both vegetations is said to be equal if the similarity value of the two vegetations is > 60%. This difference was influenced by interaction patterns that could be formed between the weed communities and the fruit crops. That result also is significantly influenced by two species, that is *Galinsoga parviflora* which is not invented in srikaya area but became the most dominant species in red dragon fruit's weed vegetation, and *Emilia sonchifolia* which is not invented in red dragon fruit area but the most dominant species in srikaya's weed vegetation. In the other hand, srikaya's weed vegetation is dominated by herb species, but red dragon fruit's weed vegetation is dominated by shrub species. It can be influenced by canopy cover of main plant and root system of main plant. The dragon fruit canopy is narrower than srikaya canopy. It makes light intensity in the dragon fruit area higher than srikaya area, so that herb can grow as good as in srikaya area.

From the measurement of abiotic environmental factors, the researchers obtained information about environmental factors comprising soil pH, light intensity, and soil moisture. The soil pH was between 6.6 and 6.7. This shows that soil tended to have a neutral pH, so that any plant including weeds can grow well (Fig. 1). The measured light intensity was between 400 and 720 lux. This shows that the light intensity was high enough although some of the sun light was blocked by the red dragon fruit plants. Such a light intensity would allow many species of weeds to grow well (Table 2). In addition, the measured soil moisture was not more than 1.5%, and the average of soil moisture level in each plot was 0.7%. This soil moisture was quite low, so that the growth of some

Table 2 Number of weed individual and weed species around dragon fruit and Srikaya fruit plants.

Parameter	Dragon Fruit Area	Srikaya Fruit Area
Number of individual	1401	1159
Grass	43	62
Herbs	378	585
Shrub	980	512
Number of spesies	31	27
Grass	9	6
Herbs	11	10
Shrub	11	11

weed species was inhibited, especially weeds belonging to herbaceous species that require a lot of water supply. In the other hand, soil moisture relate with soil compactness. Soil compactness variable showed correlations with species richness and the cover values of the species. Moreover, soil compactness is related to high clay and organic matter content which exhibited significant differences between mountain and lowland farms [12].

4. Conclusion

The structure and composition of weed vegetation in the dragon fruit farm responded to soil condition, rooting systems and psychochemical condition of dragon fruit plants. The formation of the structure and composition of the weed vegetation could be attributed to a possible reciprocal relation from the interaction patterns between the weeds and the dragon fruit plants. The dominant shrub weeds around the dragon fruit plants were related to their ability to endure being squeezed by the dragon fruit roots and thrive on soil with low moisture. This interaction pattern did not always have a negative impact as it can correlate with the increase in productivity of dragon fruit plants.

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Modern Environmental Science and Engineering (ISSN 2333-2581)
September 2017, Volume 3, No. 9, pp. 667-674
Doi: 10.15341/mese(2333-2581)/09.03.2017/008
Academic Star Publishing Company, 2017
www.academicstar.us

Genoa in the Second Part of XX Century: An Analysis through Contemporary Migrations

Enrico Bernardini

Department of Education, University of Genoa, Italy

Abstract: Genoa knew, as well as other town in Italy, a fast development during the Italian economic boom (1958-1963), marked by a great urbanization of the city. This phenomenon took the construction of new neighborhoods, the demolition of others in the early 70s, the fast improvement of the port in the 80s and changes in economic, political and territorial order.

It is also the era of great songwriters as Gino Paoli, Luigi Tenco and Fabrizio de Andrè who, with their music, described a Genoa with a particular attention to its neighborhoods and its people, places sometimes considered marginal and where often resided "the last ones", like in the case of De Andrè.

Genoa changed its face for Expo 92, event that allowed the entire renovation of Old Port area, thanks to the architect Renzo Piano. The city also saw a migration from abroad, mainly from Africa and Latin America. Actually foreigners in Genoa are about a tenth of the population and this paper wants to show, through an analysis of available official data, as they changed the traditional structures of the neighborhoods, their distribution in the urban areas, bringing colors, smells and flavors and also developing successful business activities.

Key words: Genoa, urbanization, De Andrè, architecture, migrations

1. Introduction

"*In the districts where the sun of the good Lord*
gives not its rays,
it already has too many commitments
warming the people of other neighbourhoods."

(Fabrizio De Andrè, The Old City)

This paper, using the available data provided by historians, geographers, public and private organizations, wants to frame the evolution of Genoa from the post-war period to the present, focusing on city planning, geographical, ethnic and social changes. In fact, the social context is important as well the interest for the "Old City" and contemporary migrations.

Corresponding author: Enrico Bernardini, Master; research areas/interests: contemporary migrations, sustainability, ecology, urban geography, cultural anthropology and ethnology, medical anthopology, Brazilian studies. E-mail: enrico.bernardini@edu.unige.it.

The analysis starts from Italian economic boom, as a fulcrum for the development and urbanization of the "Superba", with the construction of new neighbourhoods, also showing the negative side of the period, in other words the concreting or "rapallizzazione" of entire areas which caused issues related to citizen safety, because many buildings were too close to Genoeses rivers as Bisagno, Polcevera and related tributaries.

The building urge of the moment led to disastrous decisions such as the destruction of one of the historic districts of the city, "Via Madre di Dio", as well as the abandonment of the "Old City" as a place lived by marginalised.

Fabrizio de Andrè, a leading figure of the Genoese School, told about the last ones, in a unique manner, where it mix respect, passion, life, poetry in describing the adventures of the inhabitants of the "Old City" with their passions, sometimes uncontrolled, the strengths and weaknesses.

Then the focus moves to the renovation and the Port, a springboard for the revival of the Jetty Area, mostly transformed thanks to the plans of the great Genoese architect Renzo Piano, who was in charge of the design for the Expo 1992, where it was launched the Aquarium of Genoa, the best known and most visited tourist site in the city.

From the late 90s onwards, the Ligurian capital became more and more crossroads for migrants of different ethnic groups and, before "the Old City", then some municipalities as the West Centre and East Centre, took on the characteristics of a multi-ethnic and multi-confessional reality.

Currently foreigners in Genoa, messengers of new colours, visible from the shop signs that paint some streets, are about a tenth of the residents and the percentage increases when we speak about the enrolment in city schools.

This number obligates to reflections on municipal, regional, state and European host politics in fact, in the absence of integration programs and reforms, they risk becoming the new poor, new marginalized mentioned by De Andrè in his songs.

Likewise necessary is a basic teacher's education about other cultures, basis to build dialogue at school, starting point of a real integration of migrants in the society.

2. Genoa during Italian Economic Miracle

The Italian economic boom, generally, was an historical period that went from 1958 to 1963, according to the definition accepted by contemporary historians. As underlined by the Italian academic Guido Crainz in his work "Storia del miracolo italiano" (History of Italian miracle), understand all the profound transformations that invested in those years the society of our country it is a daunting and complex assignment.

In fact, there was a profound break with the past: the great industrial development, thanks mainly to the growth that met the North Italy with Fiat in Turin, the emergence of the Port of Genoa as Italian and international reality, passing through the changes, even at psychological level, whose protagonists were the people like in the way of thinking, dreaming, living the present and planning the future [1].

Consumption grew enormously in those years and Italy began to talk about the society of mass consumption; the lifestyle, the services and merchandises usable by the community became standardized, promoting by television, which arrived at millions of houses until to influence the lifestyles with new products, targeted programs for modelling the identity of a country in constant and sudden transformation.

The most interested areas were Turin, Milan and Genoa, who formed the so-called "industrial triangle" and brought the arrival of many unemployed coming from the south in Liguria, Piedmont and Lombardy, looking for a job in the factories and in the port of Genoa. In fact, these regions saw almost redouble the population, in agreement with the overall rate of employment, in the end of 50s and early 60s.

The wellbeing in the country can be measured nowadays through the analysis of several factors such as the growing up of automotive industry, iron and steel industry and distribution of electrical appliances, real revolution compared the past.

Do not forget the great expansion of supermarkets, especially in big cities: the introduction in Italy will bring many benefits to the population, but at the same time will cause the crisis of little shops that have difficulties to handle the competition with large distribution chains.

Like the historian Paul Ginsborg wrote, between 1958 and 1963 the rate of growth of Italian P.I.L. increased to 6.3%, such a high level that it was never reached in the history of Italy [2].

The causes of the economic miracle are more than one: from the financial market, thanks to cheap price and high yield of government bonds that led to a great purchase, the establishment of MEC (European

Common Market) in 1957 which provided the free movement of merchandise, people and capital in the Countries, the important role of the Italian state which expanded the construction of the motorway network. Italy also developed a stable policy with ENI and IRI, the two major companies of the energy market.

It is important to underline the technological growth of some strategic sectors such as iron and steel, chemical and engineering industry.

But the main factor for the development of our country was the high availability of cheap labour, thanks to the internal migration that caused a depopulation of the countryside and a movement of many people from the south of Peninsula towards the "industrial triangle".

The state didn't control the phenomenon and this fact led to the born of several critical elements and imbalances in the country, as the sharpening of differences between north and south, the growing abandonment of agriculture in favour of the expansion of factories and industries, the persistence of a ruling class, especially in the public sector, as wrote Crainz, driven by conservative tendencies, also fed from the historical period crossed by the Cold War [1].

Genoa was the protagonist, together to Milan and Turin, of this historical period, characterized by a strong intellectual fervour in the entire Italian territory, as well as by a sudden acceleration of industrial production and an improvement in production and consumption.

3. Genoa before and after Economic Miracle

As the geographer Pietro Barozzi wrote "the Genoese urban structure descends largely from choices not always knowledgeable and often imposed by the characteristics of the place, which produced and accentuated significant functional imbalances. We can find the recent origin in 1926, when 19 surrounding municipalities became part of the city, without to be prepared with suitable instruments to dictate large development lines, for which the formation of the 'great Genoa' was rightly defined an urban choice." [3]

The 1926 was a very important year for the construction of the city as we know it today, in fact, they were annexed at the territory of Genoa municipalities before independent as Nervi, Sestri, Voltri, Borzoli, Quarto, Quinto, Bolzaneto, Sestri Ponente, Sampierdarena and others.

Curiously, talking with elderly, especially in Nervi and Sestri, the people often feel themselves like "Nerviesi" and "sestresi" and not Genoeses, as to emphasize once more the ancient wrongs they have suffered caused by the fascist regime.

During the Second World War the city was badly hit by the bombing that destroyed many buildings and properties; after the war a priority objective of the institutions was a reconstruction as quickly as possible. So the Municipality made many interventions in the "Old City", sometimes not in line with the preservation and protection of the environment and citizens' intentions.

The main areas of work were two: Portoria, which involved the destruction of the ancient Doria Door (Porta Doria) and the demolition of the old hospital called "Pammatone", where now there is the Tribunal, and Mother of God Street (Via Madre di Dio), as well as the surrounding area until the border with the district of Jetty (Sestriere del Molo).

The district of Portoria was replaced today by Piccapietra but the municipal order that made more stir was that relating to Mother of God (Via Madre di Dio), concluded in the early 70s. In fact, the demolition of the area was not a direct consequence of the bombing, but it was the implementation of a regulatory plan of 1957, which modified one of 1932[1].

The residents were not consulted but placed in other districts of the city. Other ideas that considered a reorganization of the area were not taken into account; those projects provided for a maintaining the beauty of the historical sites, such as the native home of the

[1] We can find information about the regulatory plan of the Municipaly at the website: http://www.polis.unige.it/rco/rapu/pagine/schede/scheda%2034.htm.

violinist Niccolò Paganini, who lived in Passo Gattamora [3].

Instead of the historic area they built a few buildings like the “Directional Centre” or “the Ligurian Centre”, which became headquarters of public and private institutions.

In addition, it was created a green area called “Gardens Baltimore” or “Plastic Gardens”, demonstrating the lack of affection that the Genoeses have for the place. The green area became in the evening a place for criminals and addicted, cancelling so the spirit of renovation of the Municipality.

Fig. 1 Mother of Good Street (Via Madre di Dio), 1880 (Photo by G. Sciutto — Photographic Archive of Municipality of Genoa).

Fig. 2 The “Directional Centre” or “the Ligurian Centre” built instead of Via Madre di Dio. [4]

It’s in these years that Genoa has further changed colour, where the brick was the lord, also because of the economic miracle and a great increase of population which led to an urban explosion, that the *Mass Media* judged irrational and disorderly.

Barozzi reported the data from 1936 to 1965 showing population in Genoa grew from 634.646 inhabitants to 848.000 [3]. Data is interesting at the light of the fact that currently the residents are 580.000, then even fewer than in the 90s. The first areas that were interested by a copious “rapallizzazione” were the hills of San Fruttuoso, Sampierdarena, Rivarolo and Marassi, where buildings were built wildly considering just of the space to allow free movement of vehicles, including along the rivers Bisagno and the tributaries. Unfortunately, this way of building without taking into account the environment and the rivers played a key role in facilitating the floods of 1970, 2011 and 2013.

Even social housing was involved in this process: always in the 60s were built palaces on Quezzi heights, known as “Il Biscione”, the shape remind a large snake, where many people went to live. The new urbanization weighed on the city streets and the suburb became a tangle of buildings and medium and large industries that impede themselves each other in an effort to expand due to the proximity of the roads.

In the periphery born other settlements just as disorganized, for example the Begato district, born with the purpose of connecting the agricultural area with the town, instead obtained the effect of catalysing many members of the Genoese criminality because of the distance from centre; it is accessible in long hilly roads become over time a sort of open dump and like other housing complexes such as “Quarto Alto” does nothing more than defacing an already damaged natural environment.

In the topography of Genoa’s historic centre designates the city area included within the “Walls of Barbarossa”, but it is also the name given to the area of the Sestriere di Prè, the Jetty (Il Molo) and the Magdalene (Maddalena); so the area interested by the

"Old City" it is actually much broad than that traditionally attributed.

Gazzola underlined in "Genova: urban dynamics and deviance" that in the post-war period, the Historical Centre, as well as damaged by bombing, became the place that hosted several traffics and immigrants, marginalized, unemployed, delinquents [5] "thieves, the killers and that strange guy"[2] of Fabrizio De Andrè, as we shall see in the next paragraph.

4. Genoa and Music: The Genoese School

The Genoese school was a musical, cultural and artistic movement of profound break with the past developed in Genoa since the 60s around artists like Luigi Tenco, Fabrizio De Andrè, Bruno Lauzi, Umberto Bindi and Gino Paoli. The break was not only for the style, but also and especially with regard to topics covered: feelings, passions, sometimes told explicitly, political ideology, connected to socialism, anarchism and antimilitarism as a reaction to Vietnam War (1961-1975).

But the biggest influence was beyond any doubt, especially in the case of Fabrizio De Andrè, Bob Dylan's folk music, French existentialism and American poets and writers of *Beat Generation* like Jack Kerouac.

The themes of the songs are various, but thanks to Faber,[3] the focus moved to the margins of society, such as homeless, addicted, prostitutes and gypsy and the neighbourhoods where they lived, the so-called "old city".

Genoa is the background to the works of the intellectual group but if, in Bindi, Tenco and Paul, the city is almost never mentioned directly for leaving space to love, sometimes tormented, in De Andrè and Lauzi the Ligurian capital is recalled in the texts even with the use of the local dialect, the Genoese.

It's a Genoa post economic miracle, full of industries and flourishing in the port, involved in student demonstrations in 1968 in the hope of changing the world, as well as in other European and USA cities. De Andrè portrayed the historical centre in all of its aspects, its virtues and vices, its passions and flaws, always with a delicacy and respect in recounting the adventures of the various "characters", erected to gods in a Pantheon of miserables. For example, in the last part of the famous "The Old City" (1965), talking about some characters that lived in the historic centre, Faber reminds us:

"...If you'll think about it, if you'll judge it
as a good citizen
you'd condemn them to 5000 years of prison adding the costs
but if you'll understand, if you'll investigate even deeper
if they are not lilies, they are still sons
victims of this world."

There are in the song some important aspects: the political theme, the rebellion against the conformist and Catholic moral, a legacy of Fascism, the desire to understand, not to judge by appearances, despite everything, these people. Indeed "*nothing is born from diamonds but flowers grow on manure*", famous verse in the last part of "Field's Street" (Via del Campo), 1967, it is a real gesture of affection and love towards those who were considered "outcasts" and, this case, "prostitutes", almost as if the purity and true love could only be found in what is considered the most impure by bourgeois morality. The historic Centre of the city, after the massive damage suffered during the Second World War, went through a period of sharp decline, as demonstrated by the Genoese singer-songwriter songs. One of the areas most affected by the bombing was, as described in the preceding paragraph, the nearby location for Sarzano Square (Piazza Sarzano); so Mother of God and other alleys were destroyed in the early 70s to leave place for new buildings and gardens. A song by Fabrizio De Andrè and the famous Roman singer-songwriter Francesco de Gregori, The Way of Poverty (Via della Povertà/Desolation Row), released

[2] Verse of *La città vecchia (The Old City)* by Fabrizio De Andrè.
[3] Nickname given to Fabrizio De Andrè by the actor and friend Paolo Villaggio.

in 1974, even if it is the Italian translation of Desolation Row by Bob Dylan, takes us back with thought to the Mother of God, inhabited by the poor, immigrants and the homeless, always treated with great respect by the artists, but eternally condemned to poverty, places where even simple letters cannot be send.

In fact, we read:

"..All these people that you mention
Yes, I know them, they're quite lame
I had to rearrange their faces
And give them all another name
Right now I don't feel so good
I don't want your letters no more
Not unless you mail them
From Desolation Row"

Bruno Lauzi understood several aspects of the Ligurian capital with its "Genoa for us" (1975), where the focus is not the city but the nature of the citizens, the "churlish people". The song was not written for the Genoeses, the "us" of the song are not those who live in the city but, for various reasons they are captured and fascinated until to remain in Genoa forever.

In fact, we read in the first verse:

"With that iffy face
that iffy expression
we have before leaving for Genoa
and every time we wonder
whether that place we are going to
will swallow us and we'll never come back."

But the thing that the interpreters of the Genoese school have in common is the love for the sea and the importance of living close to it; the sea is mentioned in the songs of all the authors, De Andrè, Lauzi, passing from Tenco and Sapore di sale, great hit by Gino Paoli.

The artists and songwriters witnessed of the great changes of Ligurian society like student movements of 68th, the transformation and urbanization of Genoa, the abandonment and rebirth of the historical centre since 1976, but also tragic events such as the suicide of Luigi Tenco during the San Remo Music Festival in 1967.

5. Genoa and the Old Port

The port has always been inextricably connected to the history of Genoa, from its founding to the glory that brought Andrea D'Oria in the sixteenth century, with its large fleet known throughout the world. All activities of the Genoese: trade, banking, shipping, finance, shipbuilding industry have always rotated around the harbour. The link with the city diminished in the twentieth century when it ended free access to the Port and there was a major economic and employment growth that made it one of the fundamental international harbours of Europe and the world. For the citizens of Genoa the harbour area is not exclusively related to the departure and arrival of ships; especially the oldest part became a tourist destination and a place of meeting. The site, called the Old Port, knew a great renovation in the 90s, particularly in 1992, when Genoa hosted the International Expo. The event was also called Colombiadi, because they remembered the 500th anniversary of the discovery of America by Christopher Columbus. The protagonist of the change was the famous Genoese architect Renzo Piano who designed and built some areas still used nowadays as the Cotton Warehouses, currently used as a cinema, conference centre, restaurants, the City Library "De Amicis", the "Bigo" (an elevator for seeing the entire Port from above), the Aquarium which was inaugurated during the Expo. The aquarium, managed by Costa Edutainment SpA, is the most visited attraction in the city by Italians and foreigners, with estimated entrances of more than a million of persons from all of the world [6].

The Old City area, which overlooks the Old Port, from 1992 onwards also was the subject of a major redevelopment with the designation of Genoa like European Capital of Culture in 2004, and especially the consecration of Rolli's Palaces[4] in 2006 among the cultural heritage of Humanity Unesco that brought

[4] "Palazzi dei Rolli" were an ufficial list of noble palaces instituted in the XVI century by the Republic of Genoa for hosting important persons in Genoa. We can find more informations at: http://www.irolli.it/.

international attention to the "old city", given the presence in the area of aristocratic residences.

6. Genoa and Contemporary Migrations

From the first part of the 90s the Ligurian capital had a strong migration, mainly from Albania and Morocco and after from Eastern Europe, Romania, in the 2000s. Later in the city came many foreigners coming from the south America and especially Ecuador, so much so that today still constitute the most numerous and active community in the Genoese context.[5] According to the latest ISTAT data updated in September 2016, in Genoa there are 54.779 foreign on 583.973 inhabitants. Basically, about one on 10 is not Italian; these data necessarily imply a greater interest of authority and politics about integration of an important reality in the Genoese urban context.[6]

This change has had and continues to have consequences also on urban planning: the change in Sestriere of Prè, located in the District East Centre, from the neighbourhood of marginalized narrated by De Andrè's has become a neighbourhood inhabited mainly by immigrants, perhaps equally marginalized, but they brought new languages, values, cultures and colours, drawings, signs visible in many shops and ethnic restaurants. The migrations and economic crises divided in two Genoa, where foreigners have settled substantially in several neighbourhoods, leaving others for economic reasons related to the cost of living.

The report of the City of Genoa, "Genoa, Foreigners in 2015", shows some interesting data: the South Americans are the most numerous and constitute 35% of the total, followed by non-European citizens (17.8%) and Europeans (14.7%). In the end we find Asians (13.2%), the North Africans (10.1%) and finally the people from other American and African countries [7].

Specifically, the most represented is Ecuadorian community with approximately 15.000 members, behind them there are Albanians, 6.093, and Romanians (5117). The numbers of Moroccans Decreased to 4.187, because of many returns at home caused by the favourable economic situation in Morocco, followed by Peruvians, Chinese (difficult to quantify for the closure of the community), Ukrainians, increased, especially women for the growing demand of elderly's care in Genoa, given that 28% of residents are over sixty age. The most marked African presence is Senegalese (1.780), followed by Nigerian and Tunisian. The Asian community is also represented by Sinhalese (about 1.150), Bangladeshis, Indians and Filipinos.

Talking about the distribution on the territory, the West Centre district, the area of Sanpierdarena, has the highest number of foreign residents, nearly 11.000, followed by the East Centre district, the Port area and the Old Town, 10.346. Together the two districts hosted 40% of foreigners residents in Genoa, followed by Val Polcevera district, 15.3%, Middle West district, 11.1%, Val Bisagno district, 7.6%. At the end there are the Middle East district, with 5.4% and the East and West districts [7].

7. The Foreigners in the Genoese's Schools

Analysing the data provided by Arsel Liguria, Regional Agency for Educational Services and the Work, related to school year 2014/2015 there was a general increase of foreign students than in previous years. Overall, considering state and private schools of all levels, non-Italian students are 18.743 on 161.233 units. Statistically, the percentage reached 11.6% with a clear majority in the province of Genoa with 54.4%, followed by Savona, Imperia and, finally, Spezia [8].

The data confirm the history of migration and distribution of the new arrivals in the Genoa area. The major concern primary school enrolments, 7.488 on a total of 61.658 children. These data make us reflect on some factors: first, the desire to settle in the region from parents and to build a life in Liguria and try a integration with the territory; *in secundis* should lead

[5] Data are confirmed by the report of the City of Genoa, "Genoa, Foreigners in 2015"at: http://statistica.comune.genova.it/pubblicazioni/download/stranieri_ge/Stranieri%20a%20Genova%202015/Stranieri%20a%20Genova%202015.pdf.
[6] Data published iat: http://statistica.comune.genova.it.

the state to some considerations concerning the education of teachers, especially in primary school.

New smells, tastes, colours, bring with them new hope and the role of the teacher will have more importance in a context always more multi-ethnic. Educating at intercultural values and cultural relativism also means this: face the challenges that puts the future in an open, aware and respectful way of the "other", in an inclusive perspective and always reminding us that the Italians were and still are a nation of migrants. In this sense, a teacher educated in accordance with these principles can make the difference because a child including today will be a man (or woman) more integrated in the future society. The teacher will also have the task of recognizing "the other" not for exclude it, but for include it, enhance it in a society always in constant transformation.

8. Results

The urban planning of Genoa has changed, often in the name of brick, from the 50s to the present day. It has been 60s, economic growth, and the will, often inconsiderate, of modernization at all costs. Unfortunately, the city lost a lot, and the historical neighbourhood of Mother of God Street (Via Madre di Dio) which hosted Paganini's home, even the Door of Doria (Porta dei Doria) close today's Piazza Corvetto was destroyed because of wicked politics.

The "Old City", celebrated by songwriters like Fabrizio De Andrè or musical groups belonging to the Ligurian folklore as "I Trilli", has been for years place of decay, but with time the marginalized who lived in the "carruggi" were transformed into new outcasts, migrants who cannot find integration paths in our country. The analyzed researches show how foreigners in Genoa are still rising and that they have helped to bring new colors in our streets and new flavors in our kitchen if we consider, for example, diffusion of a dish of the North African tradition as the "couscous" in many Italian regions.

The recognition of different value has to start, beyond by civil society and politics, above all by the school and the main message of this paper is that teachers of the future will have to consider a training course in the sign of interculturalism and relativism, in order to carry out their job, their mission of teachers and educators of future generations.

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