In a Constant State of Flux

Embracing Impermanence of Colors in Natural Ink

Droplaug Benediktsdóttir

A document submitted to:
The Department of Design and Architecture, Iceland Academy of the Arts, in partial fulfillment of the requirements for the degree of Master of Design, 2015.
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Abstract

This research project demonstrates my admiration for colors found in my closest environment, Icelandic nature, and how I used these colors as inspiration for a local color palette and as ingredients for creating biodegradable ink. Working with living materials makes the process of creating the ink tricky and it produces surprising results, as the color seems to be changing constantly over time. By embracing the qualities of the ink changing, it can offer an alternative for people interested in using biodegradable ink for printing and painting.
“Color is not an object out there in space, waiting to be named; it is a phenomenon, an event that happens between an object and a subject”

Bruce R. Smith
Acknowledgements

My interest in working with natural ink sparked when I was researching an Icelandic artist and philosopher named Sölvi Helgason (1820-1895), whose artwork influenced me to start looking into ink making and color theory.

I would like to thank Guðrún Bjarnadóttir, a botanist and owner of Hespa, a brand that makes and sells yarn dyed with colors extracted from Icelandic nature, for her guidance in knowing the plants I was using for teaching me about traditional methods of extracting colors from the environment.

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Introduction

I cannot imagine a world without colors. Their existence is of such profound importance to me and the work that I do as a designer, which makes it exceptionally hard to even try to understand how the world would even function without them. Colors both have a personal and a professional meaning to me; as most people, I do have my favorite and my least favorite color, and in my work I have to consider the relationship between the color and the design, and explore it from many different angles.

That is precisely the spark that started this research project; taking my admiration for colors found in my closest environment, Icelandic nature, and used to create a biodegradable alternative in ink making. The use of the nature is twofold; as inspiration for a local color palette and the use of Blueberries and Crowberries to create the actual colors of the ink.

In the course of this project, I dived into learning about ink making and various methods of printing with ink, compared petroleum based inks with biodegradable alternatives and looked into the environmental risks they presumably have. I briefly examined the printing industry and packaging and what happens to it after we use it; the degradation process and whether the ink itself is an environmental risk at all.

When I decided to undertake this research topic I had predefined ideas regarding results of what the ink I wanted to produce should be. I wanted to create natural biodegradable ink that was compatible with mass produced petroleum based inks, which have (along with a few other) toxic components in them, which help the color staying permanent and therefore giving the consumer a guaranteed result. I wonder whether this premature outcome of what I imagined as a result for my inks would be, could be influenced by cultural values and the society around me. Could it be that my disconnection with embracing the ephemeral is because of where I was raised and the values society influenced me to always seek permanence and perfection?

Working with natural ingredients does not give the same color result as synthetic colors, because the ingredients are living materials that constantly change over time.
For my own experiments with making natural ink I am looking into my nearest environment, Icelandic nature, seeking inspiration for the range of extractable colors and look at how the harsh climate and extreme seasonal changes affects or limits this process. I will look at traditional methods of creating color, methods that were practiced for centuries before the arrival of the industrialization in the mid nineteenth century, as well as Icelandic traditions.

I will be looking at the value of colors in today’s society, how we as human beings perceive them differently as individuals and as cultural compared to their value before the industrialization, when petroleum inks replaced natural substances and much cheaper synthetic colors came along. I will also examine the environmental risks of these inks. Furthermore, I will look at what the value of colors is in different societies and how we

The core task at hand for this research project is to make biodegradable ink made from Blueberries and Crowberries gathered in Icelandic nature and to observe the ink over time to see whether it could become a usable alternative to petroleum based inks; being a more environmentally friendly alternative as well as giving different colors from the petroleum based ones and therefore a different aesthetic appeal. I want to find a way to work with the natural ink by embracing the impermanence of it, and how that could benefit as an alternative in printing, offering a different, impermanent results where the ink might disappear or fade in time, without causing the natural environment any harm.
Background

1.2 Why Natural Ink?

Using colors extracted from plants, whether that is for use in dyeing processes for fabric and wool, or to make ink or paint out of them, gives a very different aesthetic appeal from synthetic colors. Due to quality differences in different provenances of the dye plant, natural dyes have much broader variations in color tone than synthetic dyes.¹ For some it could be looked at as a disadvantage to natural colors that they take longer to dry and it is more difficult to maintain the same exact color for multiple applications, the colors always vary depending on how you are mixing them. So for a mass production of, for example, packaging’s printed with natural ink might not all look the same. Synthetic colors do on the other hand offer a more permanent, fixated outcome, which seems to be an advantage to many consumers.

Today, the use of natural substances for colouring belongs mostly to a niche market that exist worldwide, most often businesses either selling natural ingredients, for example in powdered form, and the consumer mixes it following directions to dye fabric for example. Or businesses selling products that were made using natural coloring methods, such as Hespa, an Icelandic brand selling naturally dyed yarn. There are also the occasional craftsmen and practitioners seeking a more authentic look for their products or work. Synthetic colours are used commercially worldwide, mostly because they are cheaper, dry faster and offer a permanence in the colours. ² This will be discussed further in chapter two.

2.2 Working with limitations / Icelandic nature

Iceland is a remote island located in the north-Atlantic ocean, therefore belonging to the northern hemisphere. It’s unique location, cold weather conditions and frequent seasonal changes can make it exceptionally challenging for plants to thrive.

¹ Natural dyes: their history and how to use them
² Varenya, “Natural Dyes”
The earth’s axis is not perpendicular on its route around the sun, instead it tilts 23.5 degrees, which results in the northern hemisphere sometimes turning towards the sun and sometimes away from it, creating a cycle of four extreme opposites seasons. All life on earth thrives on the energy the sun gives it, making the plants that grow on the island unique. These vascular plant species have adjusted the harsh and ever changing climate, surviving frost, which only 25% of the world’s vascular plants do.

From growing up surrounded by it, I have attained respect and admiration for the unique color range Icelandic nature can reflect and learned to appreciate its frequent shift in colors from one season to the next.

I experience the colors in fall as bright red and yellow, found in all the withering leaves lying around slowly disintegrating; the winter brings cold darkness which creates a spectacular contrast of black and white, where snow meets rocks and lava formations. The lack of sunlight creates a scale of grey tones in the sky but at times you can spot in the distant horizon a range of red, yellow and orange colored sunlight barely peaking, but reassuring us that the colors are still around during this ‘dark time´ and will return soon; spring marks the beginning of what is to come: summer. Suddenly everything starts blooming, the snow disappears and birds return from their travels to warmer countries over the wintertime and start singing for us at all hours of the day. The days start getting longer, and in June the day never ends, offering visibility of the bright green moss stretching as far as the eye can see, variegation of different flowers and plants, fields of purple lupines and the grey winter colors of the sky are replaced by ranges of colorful displays.

These extreme opposite seasons bring along something very magical, inspiring and energizing, reminding us that everything is indeed impermanent and in a constant state of flux.

But these seasons also make it more difficult for Icelanders to use the natural ingredients available in order to use them for whichever purposes, e.g. for creating medicine, creams and lotions and as it is in my case, as natural pigments for the ink making. The opportunity to gather plants in order to use them as the natural pigment is short, e.g. the berries I use for my ink, Crowberries and Blueberries is in late August until around mid September. This can vary a bit between years though; sometimes they arrive later and sometimes earlier, depending on what the weather has been like.

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3 Baldursson, Lífríki Íslands, 10.
4 Baldursson, Lífríki Íslands, 14.
2.3 Environmental risks of ink

In order to understand why biodegradable inks could provide an environmentally friendly alternative to the more commonly used petroleum based inks, one has to realize the basic components of inks and why they are presumably bad for the environment, wildlife and people.

Fundamentally, inks are made of three basic components. These components are pigments; which provides the actual color of the ink, oil; which provides the smooth application of the ink and varnish; which has the role of protecting the pigments from being smudged off and gives the ink a glossy finish.

As mentioned above, the oils used for these inks are commonly either petroleum or mineral based which contains toxic elements, and the pigments used frequently contain heavy metals, which means that when the printed surface (packaging, cardboard, posters and paper) is left outside to degrade, the pigments and oils start polluting the soil.\(^5\)

These chemical based inks were introduced in the beginning of the nineteenth century, when the Industrial Revolution came along and revolutionized entire industries, including the printing industry. These revolutionary chemical based inks dried a lot faster than the natural inks, allowing printers to print more and overall increase the productivity of the printing job.

The main harm these chemical based inks have on the environment are threefold: Volatile Organic Compounds, or VOC’s, which enables the fast-drying time of the inks; Non-renewable oils, the oils used for petroleum based are non-renewable, hence, we can not grow more oil when it runs out; Heavy Metals, the pigments used for many petroleum based inks have for example the chemicals Copper and Zinc in them which are heavily toxic and can be carcinogenic. These pigments also make it impossible for the inks to biodegrade.\(^6\)

It is important to keep in mind that these risks caused by petroleum based inks depends on various factors of how the inks are handled, which health regulations and conditions workers in printing facilities are and which ink product is being discussed.

\(^5\) Ryan, “Biodegradable Inks”
\(^6\) Sustainable Graphic Design
Review of the Literature

3.1 Brief History of Color Production

Today, color is all around us and connected to almost everything we do and see. It seems to me, that many people do not even really contemplate their existence; they seem to have become such a matter of course, simply an object out there, but still being used for multiple purposes affiliated with our daily lives.

According to Feeser, Goggin and Tobin, authors of the book *The Materiality of Color: The Production, Circulation and Application of Dyes and Pigments, 1400-1800*, most people cannot really imagine a world without colors. They discuss in their book what the world was like before the arrival of synthetic colors, when it was extremely labor intensive to produce colors and people worked hard on simply attaining them. The way people looked at color back then was very different to how people perceive them today, as they were not something either easy to attain nor produce.

The color industry changed dramatically in the mid nineteenth century when chemicals replaced natural substances, which was, as discussed above, used to then to create color. These natural substances were extracted from plants, natural minerals and animals, for example, red or carmine colors were extracted from the insect cochineal, and yellow was gathered from cow-urine and blue from indigo plants.

These natural dyes and pigments were used to put color to everything used by people used; yarn, threads, fabric, paint and watercolors for artists as well as interiors in houses, cosmetics, ceramics and printing to name a few.  

3.2. Value & Perception of Colors in Divergent Cultures

Every single color can have a very distinct meaning in different cultures. The language spoken in each country can greatly influence the way people from different cultures perceive and experience colors:

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According to Benjamin Whorf’s Linguistic Relativity Hypothesis a person’s language determines and limits what the person experiences. Not all concepts can be expressed in some languages. This language barrier can affect one’s perception of color. For example, the Shona language in Zimbabwe and the Boas language in Liberia have no words, which distinguish red from orange. Therefore, people fail to perceive different colors because of language limitations.\(^8\)

The very same color can have a very opposite meaning from one culture to the next. To name a few examples of this; in Western cultures the color red is symbolic for love and danger but in eastern cultures it is the color of celebration and happiness, and frequently worn by brides for their wedding. In Western cultures white is the color for purity, peace and commonly a wedding color whilst in China it is the color symbolizing death, mourning and funerals.\(^9\)

Psychologist E.R Jaench has studied cultural perception of colours and his research has shown that climate can even affect which colors people prefer. People living in colder climates tend to prefer cooler and less saturated colours whilst people living in sunnier countries prefer warmer and brighter colours.\(^10\)

3.3 Impermanence & Imperfection vs. Permanence & Perfection

Wabi-Sabi is a Japanese aesthetic ideal, which “embraces the Zen nihilist cosmic view and seeks beauty in the imperfections found as all things, in a constant state of flux, evolve from nothing and devolve back to nothing”. It focuses the mind on imperfections and how we should embrace impermanence, looking toward nature to seek truth and inspiration, since nature can surely be defined for its imperfections and asymmetry.\(^11\)

Impermanence expresses our experience of the finite world of birth and death, and is founded on the bedrock of one formulation of the three Buddhist statements

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8 Bortoli, “Colours Across Cultures”, 4.
11 Juniper, Wabi Sabi, 2.
concerning the nature of that world: (1) all is impermanent, (2) all is suffering, and (3) all is without ego or self. Everything is impermanent.\textsuperscript{12}

Buddhist thinkers often contemplated time, how we experience it and its relation to eternity, they believed in impermanence where everything changes and nothing lasts forever. On the contrary, Western thinkers looked at time very differently and believed in eternity.\textsuperscript{13}

Hellenic worldview was very dominant in the Western world, where perfection, symmetry and permanence is valued above all else.\textsuperscript{14} The Greeks formulated many of the Western world’s central concepts in science, art and philosophy. Early Greek philosophy can perhaps be understood better by looking at a quote by one of Plato's sophist and a philosopher named Protagoras (490 BC-420 BC); “Man is the measure of all things”. Unlike Eastern philosophy, man was above all, and forces of nature were personified in gods and goddesses; ...Demeter (literally "Earth Mother"), was the earth and giver of grain; Apollo, the sun and giver of light; and Poseidon, who dwelled in the sea, was the ruler of the waters.\textsuperscript{15} “In Western terms, we are dealing with the finite to the infinite, of the world to the Absolute, or God”\textsuperscript{16}.

\textsuperscript{12} Stambaugh, \textit{Impermanence is Buddha-Nature}, 2.
\textsuperscript{13} Stambaugh, \textit{Impermanence is Buddha-Nature}, 1.
\textsuperscript{14} Juniper, \textit{Wabi Sabi}, 2.
\textsuperscript{15} Guisepi, “A History of Ancient Greece”.
\textsuperscript{16} Stambaugh, \textit{Impermanence is Buddha-Nature}, 2
Research Methods

4.1 Natural Ink Experiments

A large part of my research project has been to experiment making biodegradable ink using natural ingredients gathered from Icelandic nature in late summer 2014. The main ingredients used are Blueberries and Crowberries, which act as colorants for the ink, and the liquids are vinegar, water and pure alcohol. For the preliminary ink making experiments I decided to also try to use Madder Root, which was traditionally used in natural dye productions, and Turmeric, because of its staining qualities. Turmeric produces a very strong color naturally, staining everything it rubs into (see figure 2).

These preliminary experiments demonstrated how the ink was working with the paper and gave me an insight into the possibilities it could produce. I decided that for my ongoing experiments I would focus on only using the Blueberries and Crowberries, to work with the ingredients I had attained myself from Icelandic nature.
The inks I am attempting to make are experiments built with the hope of finding a usable technique to create an Icelandic biodegradable ink recipe. All of the ingredients were dehydrated in an oven for circa 20 hours to get all the liquid out of them.

Next, the berries were ground into fine powder using a coffee Bean grinder, which was then mixed with different amount of liquids (depending on the desired color tone) acting as preservatives for the ink.

During the preliminary experiments made in December 2014, it was soon discovered that mixing the berry pigments with pure water resulted in the ink molding after circa two weeks (see figure 5). I left both Crowberry and Blueberry powder in a jar with water, and after returning from holidays I noticed a considerably large amount of mold in the jar. This made me realize that the ink needs to be mixed in with a preservative such as vinegar or vodka, in order for it to last for a long period of time.

The ink goes through a certain process before it is read to be applied. After mixing the colored pigment in with the liquids, it needs to be sieved (see figure 6) to get all the small pigments out of the liquid for the ink to be clear in order for it to produce a clear ink result.
4.2 Color Changes & Observation over time

Observing the ink over the period of five months (December 2014-April 2015) allowed me to see the changes that were occurring in the ink. There were two types of color changes happening: when the ink is first applied onto the paper, a very strong pink color appears, which changes over the period of circa ten minutes and starts fading to a blue or purple color, depending on which berry pigment is being used and how it is mixed. The tones of pink appearing at first also vary depending on the mixing method. See figures

![Figure 7 & 8: The ink drying from pink to purple](image)

![Figure 9: Color tones](image)
I observed the color changes in the ink from December 2014-April 2015, and saw how they did not only occur at first when the ink is drying on the paper right in front of your eyes, but also after having been on the paper for a few weeks. I began scanning the color samples I was creating regularly in order to see how the colors were changing exactly. Each color was scanned separately, and then over the period of circa two weeks the same color was scanned again and compared to what it had looked like before. I carried out this procedure for the entire duration of the experiments. Figure x shows five Blueberry gradient tones, the darker tones displayed were scanned on January 26, 2015 and the faded colors next to each dark tone was scanned two months later, March 24, 2015. Figure X demonstrates four Blueberry gradients showing the same process where the colors were scanned two months apart.

Figure 10: Crowberry ink tones documented over time

Figure 11: Blueberry ink tones documented over time
By scanning the color samples regularly, I also managed to keep track of each color created and documented where each one fitted in within the RGB gradient scale. This method also provided me the opportunity of seeing the same color changing within the digital RB scale (see figure 12). This proved to be a very affective method in observing color changes in the ink because seeing the same color sample in front of your eyes everyday, somehow you do not notice the change in color happening as drastically as when you see what the color has become.

![Figure 12: Digitally observing the color changes](image)

4.3 Using the ink on Plywood

I also experimented with applying the ink onto a plywood book-cover (see figure) to see how the ink would react on another material than paper. The color seems to react very differently with plywood, and a much brighter pink color appears, similar to the one appearing when it is fresh on paper and the veins of the wood are very visible through the color when the ink is applied. It stays pink for approximately two days, after that, both the Blueberry and Crowberry ink dry into a very Similar purple color and seemed to remain fairly permanent.

![Figure 13: Plywood book cover](image)
The book-cover was painted with Blueberry ink on January 27, 2015 and then observed over time to see what would happen to the color. On March 24, 2015 I took a photograph of the book-cover again and noticed that the color had started to fade but still the purple color was highly visible (see figure 14).

The pink color that appears when the ink is fresh on both paper and plywood seems to stay pink for a longer period of time, supposedly meaning that it takes the ink a longer period of time to dry on the wood than the paper (see figure 15).

4.4 Thickener for the ink

I wanted to try to find a solution on how to make the ink thicker, in order to get a paste texture from it, to be use it for analogue printing, e.g. silkscreen printing. Since the focus of this project is to use Icelandic nature as the main source of ingredients, I struggled with
finding a natural substance that could work as a thickener. *Gum Arabic* is widely used for natural ink in order to achieve a paste from it, but not an option since it is not a local material in Iceland.

While looking for a *Gum Arabic* substitute, I found a natural substance called Alginic Acid, an anionic polysaccharide, which is distributed widely in the cell walls of brown seaweed. Alginic Acid is available in powder form, and creates a viscous gum through mixing the powder with water.\(^{17}\) The powdered Alginic Acid is originally Icelandic, as the company that distributes Alginic Acid products, *FMC*, owns and runs a seaweed factory in Breiðavík, Iceland.

I was able to use the research facilities at the *Innovation Centre* in Reykjavík in order to find out whether the Alginic Acid would possibly work as a thickener for the ink. The facilities at the *Innovation Centre* provided me with all the equipment needed and I carried out the experiments for three days.

I made three different levels of viscosity, but when I mixed the ink into the gum paste, it did not bind well together. It seems that the vinegar does not mix properly with the natural gum, and it became a jelly-like substance that was not usable as ink.

\(^{17}\) *Sodium Alginate*
Results

5.1 Presentation of preliminary results

So far I have managed to create an ink recipe that is presenting very promising results when applied both onto paper and wood. It is interesting to see how these materials react differently to the ink and how the ink is working with them.

Trying to achieve a complete color scale with the two inks is challenging, and having guaranteed results of the colors always being the same is hard to prove at this stage. Regarding finding a thickener for the ink, the alginic acid did not prove to be working well with the ink, but it needs more examination in figuring out how these natural substances could work together in creating a paste.

During this process I have had to learn how to see the opportunity in learning how to work with something new that has unpredictable results. Soon after starting the first experiments with making the ink, I learned that the color changes occurring in the ink was something I had little control over and I had to learn how to work with it.

I realized that it can offer a completely different result from what petroleum based inks give you, creating colors that change over time, disintegrate and become one with nature again.

I have thought of two possible outcomes that could work for the ink as a product: to offer a printing service printing on stationery, packaging, such as food packaging and other paper products, printed with the biodegradable ink. The other is to create a product out of the ink itself, a variety of differently colored Blueberry and Crowberry inks that could be purchased and used for either printing or painting with.

The ink is an environmentally friendly alternative to petroleum based inks, not having any harmful ingredients in it. In order to find out whether the ink would work for printing on packaging, further tests need to be carried out. It would be interesting to the printed packaging (if made from recycle paper) to see whether it will degrade fully in nature, both the packaging and the ink itself.
5.2 Blueberry & Crowberry Color tones

The ink is capable of producing numerous color tones, going from light blue and purple colors to dark blue and purple ones (see figures 16 and 17), and as it seems anything in between. The Blueberry ink does seem to start changing color considerably faster than the Crowberry ink, which is still a mystery and needs to be looked into further. At this stage, there is no time frame existing that demonstrates how the colors are changing over time, but it has been documented thoroughly.

Figure 16: Blueberry gradients
Figure 17: Crowberry gradients

Figure 18: Display at the final exhibition
5.3 Usability of the ink

The ink is still very challenging to work with in terms of using it for printing, as the ink recipe is quite thin and the color of the ink does not seem to appear very strong with the two methods I have tried.

I laser cut a design with the name of the project into natural rubber, which I then glued onto a block of wood. I used felt material as an inkpad, which I then applied onto the paper. (See figure 19 and 20) The result is very unclear and the materials are not working well together; the glossy surface of the rubber material and the ink did not seem to blend well. There are other stamping materials, such as foam available that would be interesting to see whether they would work better.

![Figure 19 & 20: Lasercut stamp and result](image)

I also cut out a stencil in order to see how that would work with the ink. The results are very similar as with the stamp, perhaps a little clearer, but could be refined.

![Figure 21 & 22: Using the stencil method to print with](image)
Summary

This research is an ongoing project which has only just started. The ink I have managed to develop is producing interesting and unique colors in a variety of different tones. The color of the ink produces different results when it is applied to paper and wood, being pink to purple on the wood and lighter colors in general, but on paper the color becomes darker and in a variety of darker blue colors to dark purple ones.

It still remains challenging to control the colors by trying to get the same color result every time, and needs to be tested for a longer period of time. Before the ink could become a usable product, I have to have a complete color scale from each ink, and more stability in each color.

Further experiments need to be made in order to find solutions on how the ink could work for printing. The ink recipe I have produced so far seems to be too thin in order to use it for analogue printing, with the mediums I have tried so far, as the color runs too much. This can be tested further by trying to add viscosity to the ink and to try more analogue printing options.
Discussion

There seems to be an opportunity in using this biodegradable ink for many purposes, but it needs to be developed and tested further. The colors are producing interesting results and a few color tones have been created which is a promising start to something more.

So far, a few color tones have been developed with both types of ink, but each color still needs to be defined further; I need to find a solution on how I can make sure the color tones can be reproduced again, maintaining the same color.
Bibliography


