Optimal Air Route

~Flying with the wind~

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1. Outline and Purpose:

We wondered why the airways sometimes deviated so much from the shortest route. The reasons could be due to weather conditions, priority of routes along airports for emergency landings, etc., but mainly due to the upper level wind called the jet stream. Therefore, the purpose of this study is to compare the flight time and route of the path affected by the jet stream and the shortest path, and to confirm the effectiveness of taking advantage of the wind even if it is distant.

2. Contents and Method:

Using a diagram (1) that simplifies the space to be flown, the flight time is calculated when the tailwind and headwind of the jet stream are blowing. The optimal air route affected by the jet stream is computed, using a full search (a method in which all combinations of numbers are searched). The results of each of the four levels of influence of wind on the route will be compared.

The conditions of the flight environment were set as follows:

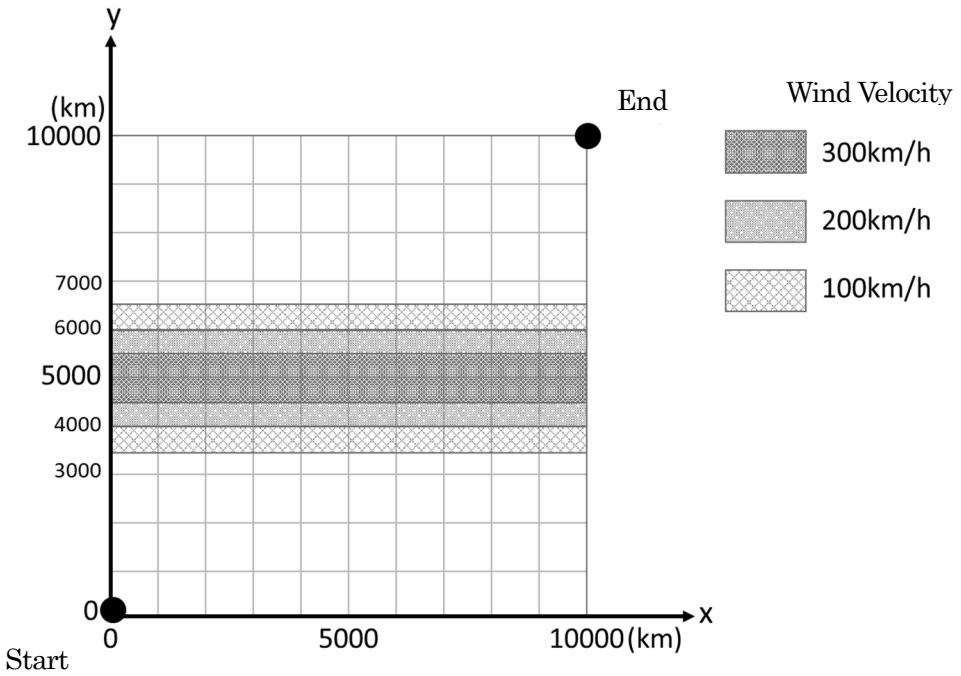


Figure (1)

- Aircraft Speed: $800km/h$
- Starting Point: Origin
- End Point: Point (10000, 10000)
- If x-axial direction is positive, the jet stream blows whose velocity is $\pm 300km/h$ in the range ($4500 < y < 5500$), $\pm 200km/h$ in the range ($4000 < y < 4500, 5500 < y < 6000$), $\pm 100km/h$ in the range

$(3500 < y < 4000, 6000 < y < 6500)$

These values were determined based on the actual flight scale to make the calculation results easier to understand. The influence of wind on the flight path was divided into four levels, (A) to (D).

A) The aircraft flies basically in a straight line, but can change direction at all 6 boundaries where the wind speed changes.

B) The aircraft flies basically in a straight line, but can change direction at 4 boundaries: the no-wind part, the 100 km/h wind speed boundary, and the 100 km/h, 200 km/h wind speed boundaries.

C) The aircraft flies basically in a straight line, and can change direction on 2 boundaries: the no-wind part and the 100 km/h wind speed boundary.

D) The aircraft flies in a straight line from the starting point to the end (shortest distance).

First, we calculate the flight time of the route (A).

Since the conditions of the jet stream in Figure (1) are symmetrical about the point (5000, 5000), we can assume that all routes are symmetrical about the point (5000, 5000). Therefore, we can calculate the path from the origin to the point (5000, 5000) in the range (0≤x≤5000), (0≤y≤5000) and multiply by 2 to get the accurate result.

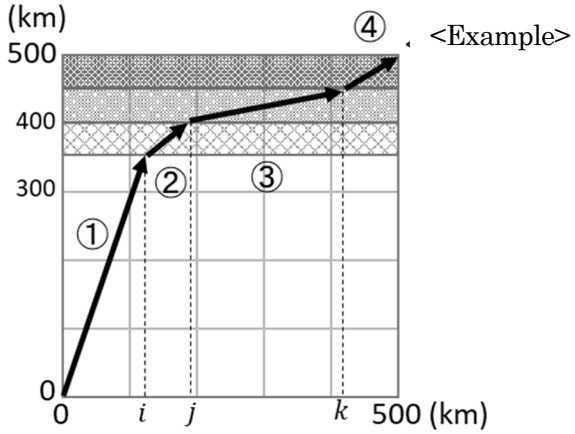


Figure (2)

When moving from the origin to the point (500, 500), the basic path is a straight line, and since the direction can be changed at three points where the wind speed changes, the route can be fixed once the x-coordinates of the three points are determined. As shown in Figure (2), let the x-coordinates of the boundary points be i, j, k (0<i<j<k<500) respectively.

The reason for the 10-fold difference in size between Figure (1) and Figure (2) is to reduce the amount of calculation when assigning numbers to i, j, and k later on. If we continue to assign (0, 1, 2, ..., 5000) to i, j, k as in figure (1), we will need to calculate about 100 billion ways, which will take a lot of time. Therefore, as shown in figure

(2), the size is once reduced to one-tenth, and then multiplied by 10 again after the calculation. i, j, and k are effectively assigned (0, 10, 20, ..., 5000). Compared to substituting (0, 1, 2, ..., 5000), there will be an error of less than 10 km, but it can be reduced to about 100 million calculations.

We divided the route into 4 straight lines as the figure (2), then let each flight time be t_1, t_2, t_3, t_4, total flight time be t, and express t by i, j, k.

$$t = 20(t_1 + t_2 + t_3 + t_4)\ [h]$$

<Line①>

Figure (2) indicates: Flight Distance: $d_1 = \sqrt{i^2 + 350^2}\ [km]$

Speed: $v_1 = 800km/h$

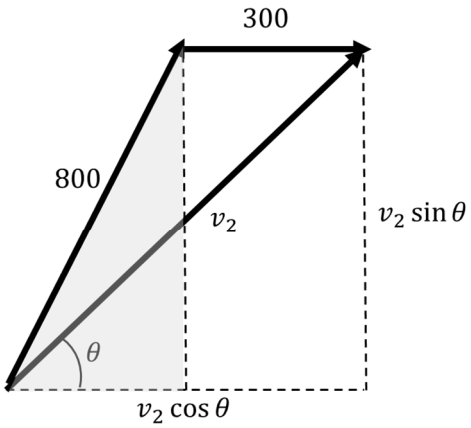
Flight time: $t_1 = \frac{d_1}{v_1}[h]$

<Line②>

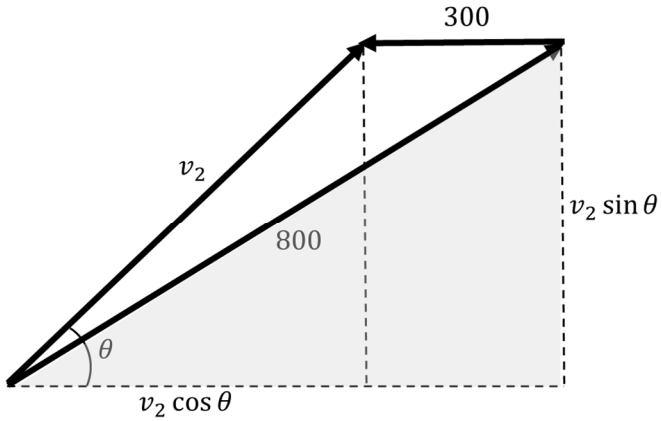
Figure (2) indicates: Flight Distance: $d_2 = \sqrt{(j-i)^2 + 50^2}[km]$

Since the speed v_2 is affected by the jet stream, it is obtained using a vector as follows.

<Tailwind>



<Headwind>



※The unit of the vector size is km/h

Figure (3)

For the angle θ between the direction of travel and the x-axis in Figure (3), the following equation can be established from Figure (2).

$$\tan\theta = \frac{50}{j-i}\ (i \neq j)$$

$$\because 1 + (\tan\theta)^2 = \frac{1}{(\cos\theta)^2}$$

$$\therefore \cos\theta = \frac{j-i}{\sqrt{(j-i)^2 + 50^2}}$$

For the right triangle in the gray area of figure (3), this equation is valid from the Pythagorean theorem.

$$800^2 = (v_2 \cos\theta \pm 100)^2 + (v_2 \sin\theta)^2$$

$$\therefore v_2 = \mp 100\cos\theta + \sqrt{(100\cos\theta)^2 + 630000}\ [km/h] (\because v_2 > 0)$$

In this case, $+100\cos\theta$ is a tailwind, $-100\cos\theta$ is ad headwind.

Time: $t_2 = \frac{d_2}{v_2}$

Straight lines (3) and (4) are calculated in the same way as (2).

<Line③>

Figure (2) indicates: Flight Distance: $d_3 = \sqrt{(k-j)^2 + 50^2}[km]$

Speed: $v_3 = \pm 200\cos\theta + \sqrt{(200\cos\theta)^2 + 600000}\ [km/h]$

$$\cos\theta = \frac{k-j}{\sqrt{(k-j)^2 + 50^2}}$$

Time: $t_3 = \frac{d_3}{v_3}$

<Line④>

Figure (2) indicates: Flight Distance: $d_4 = \sqrt{(500-k)^2 + 50^2}[km]$

Speed: $v_4 = \pm 300\cos\theta + \sqrt{(300\cos\theta)^2 + 550000}\ [km/h]$

$$\cos\theta = \frac{500-k}{\sqrt{(500-k)^2 + 50^2}}$$

Time: $t_4 = \frac{d_4}{v_4}$

We represent t_1, t_2, t_3, t_4 as $i,\ j,\ k$. The next step is to use a computer to assign (0, 1, 2, ..., 500) to each of them to find out the combination that minimizes the value of t in the whole search.

(B), (C), and (D) are the same as (A), and the flight time is represented by $i,\ j,\ and\ k$.

The route (B) cannot change the direction of travel at the boundary between wind speeds of 200 km/h and 300 km/h, so the value of k is determined by the value of j.

Because of the equation $500 - k = k - j,\ k = \frac{j+500}{2}$

The route (C) cannot change its direction of travel at the boundary between wind speeds of 100km/h and 200km/h and between wind speeds of 200km/h and 300km/h, so the values of j and k are determined by the value of i.

Because of the equation $j - i = k - j = 500 - k,\ j = i + \frac{500-i}{3}, k = j + \frac{500-i}{3}$

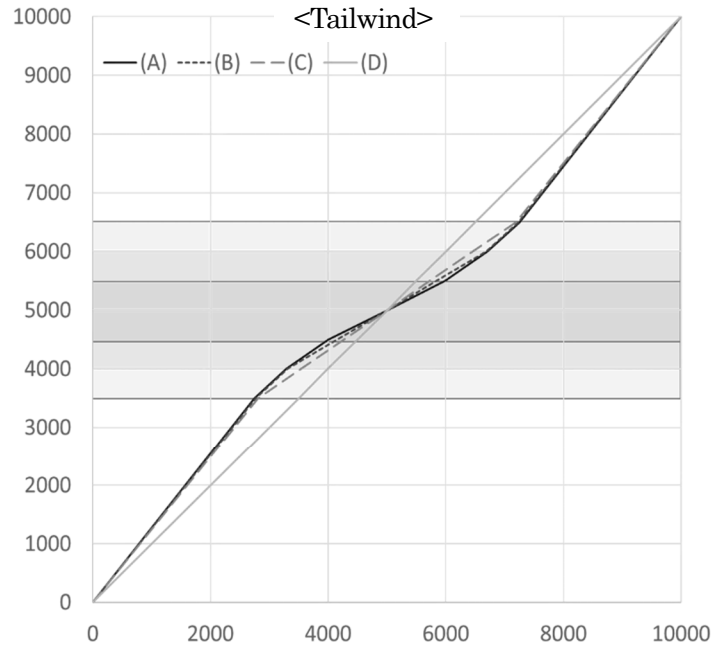
The route (D) is a straight line, so we can declare $i = 350, j = 400, k = 450$.

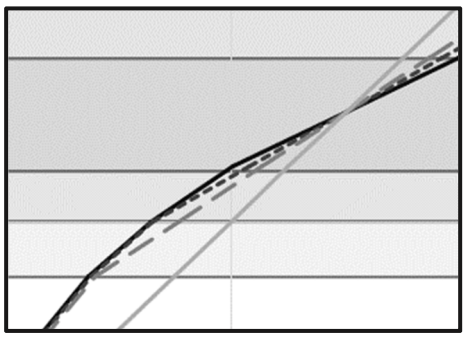
Using these methodologies, the route and flight time at the shortest time were recorded.

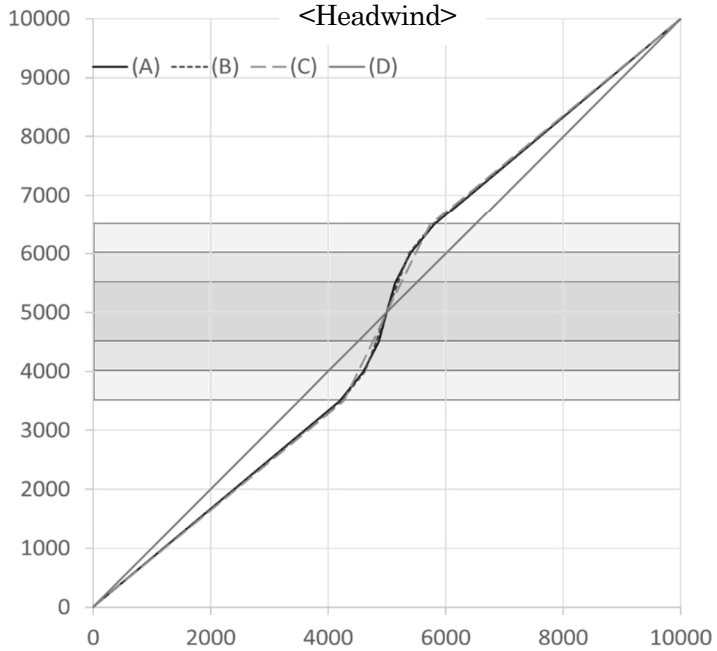
3. Results:

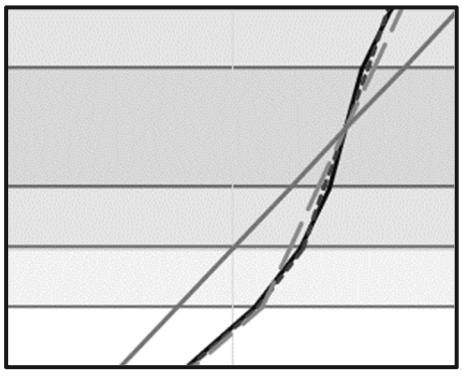
The result of the calculation of the shortest flight time, the combination of the values of i, j, and k at that time, and the route are shown on the next page.

Airway	Flight time t(h)	The ratio of (D) to t	$i \times 10$	$j \times 10$	$k \times 10$
Tailwind(A)	16.752	0.98744	2750	3290	4010
Tailwind(B)	16.765	0.98821	2770	3310	4155
Tailwind(C)	16.799	0.99022	2810	3540	4270
Tailwind(D)	16.965	-	3500	4000	4500
Headwind(A)	18.613	0.97757	4200	4600	4860
Headwind(B)	18.630	0.97847	4220	4620	4810
Headwind(C)	18.679	0.98104	4260	4507	4753
Headwind(D)	19.040	-	3500	4000	4500









The flight time was shorter in the order of (A), (B), (C), and (D), where the change of direction was easier due to the size of the jet stream, regardless of whether it was a tailwind or a headwind. In addition, the ratio of (D) to t became smaller in a headwind than in a tailwind, and the route of (B) and (C) became closer to the route of (A), suggesting that the optimal air route is more effective in avoiding headwinds.

4. Discussion and Future Direction of Research:

The optimal air route, which makes maximum use of the jet stream, has a longer flight distance than a straight line route (the shortest distance), but a shorter flight time, thus making the flight more efficient. However, in this case, the wind was blowing at 45 degrees to the straight line connecting the starting point to the end point, so it did not create a noticeable difference in flight time. In a flight where the jet stream is blowing in a more parallel direction, the power of the optimal airway will be fully displayed.

In addition, since the actual jet stream is meandering, the route will not be based on a straight line as in this case, and the amount of calculation will be huge, but it is expected to produce more practical routes.

5. References and Source Codes:

<References>

Miyatsu Yoshihiro. Yoshihiro.saitekiko-ro to Saitekiko-do no Sentei(Selection of optimal route and altitude)
（<Feature>Commemorating the Launch of the Aerospace Research Division）

<Source Codes>

https://github.com/Yuta-Kondo/OptimalAirRoute2

SEQUENCES THAT APPEAR IN FIGURES

~The geometric meaning of several sequences as seen in the generalization of the university entrance examination question~

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Instructor: Tsutomu Sato

1. Purpose:

A lot of questions regarding sequences and the figure fuse are asked on the university entrance examination because sequences appear in figures, and it is a sequence of the number which queues regularly. In this study, we aimed to clarify why sequences appear in the figures by revising and generalizing the university entrance examination questions where such sequences and figures are combined. For this, we dealt with three questions:

1. The question of considering the radius of the circle inscribed in the parabola

2. A question of combining complex number planes and recurrence formula

3. Questions with the coordinates of the center of the outer circle

As a result, it was found that:

I. The appearing an arithmetic sequence between the coefficient of x^2 in the expression of the parabola and the radius of the circle

II. The appearing geometric sequences in the area of a triangle

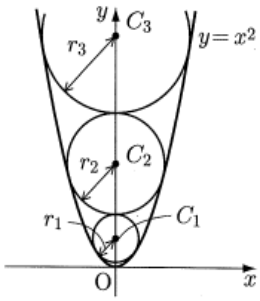
III. Harmonics appear in the x coordinates of the center of the circle

2. Materials:

We dealt with the following three questions:

[1] The circle C_1 of the radius r_1 where the center is on the y axis touches the parabola $y = x^2$ at two points. $C_n(n = 2,\ 3, \ldots)$ is a circle of radius r_n $(n = 2,\ 3,\ \ldots)$ that has a center on the y axis and touches the parabola $y = x^2$ as shown in the right figure. When $r_1 = 1$, express r_n by using n. (fig.1)

(Nagoya City University, 2013)



(fig.1)

[2] Let the sequences $\{a_n\}$ and $\{b_n\}$ be as follows:

$$a_1 = b_1 = 2,\ a_{n+1} = \frac{\sqrt{2}}{4}a_n - \frac{\sqrt{6}}{4}b_n,\ b_{n+1} = \frac{\sqrt{2}}{4}a_n + \frac{\sqrt{6}}{4}b_n.$$

z_n is a complex number. a_n is the real part of z_n, and b_n is the imaginary part of it.

(1) Find a complex number w that satisfies $z_{n+1} = wz_n$ and its absolute value.

(2) How did point $z_n$move the point z_{n+1}on the complex plane?

(3) Find the general terms of the sequences $\{a_n\}$ and $\{b_n\}$.

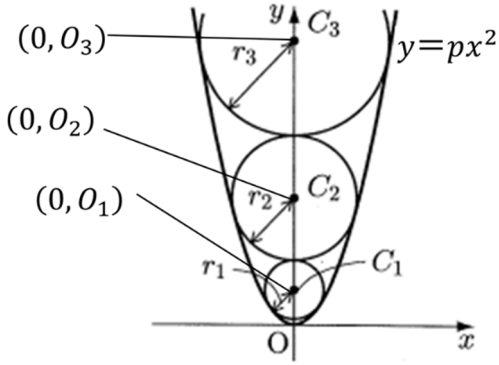
(4) Let T_n be the shape formed by filling the perimeter and interior of a triangle with vertices at three points 0, z_n , and z_{n+1} in the complex number plane. Find the area of the region filled by T_1, T_2,..., T_n,... on the complex number plane. (Kanazawa University, 2016)

[3] Let the circle C_n as follows. First, C_0 is a circle of radius $\frac{1}{2}$ centered on $\left(0,\frac{1}{2}\right)$, and C_1 is a circle of radius $\frac{1}{2}$ centered on $\left(1,\frac{1}{2}\right)$. Next, the circle that borders C_0 and C_1 and touches the x axis is C_2. In addition, C_n is the circle that borders C_0 and C_1 in order and touches the x axis, but C_n is not C_{n-2} $(n = 3, 4, 5\cdots)$. When you use (a_n, b_n) as the coordinates of the center of C_n, answer the following question.

(1) Demonstrate $b_n = \frac{(a_n)^2}{2}$ to $n \geq 1$.

(2) Find a_n.

(Nagoya University, 2002)



(fig.2)

3. Generalizations and Answers to the Questions:

The questions were revised, generalized, and answered.

[1] After the Revision

The center is on the y-axis, and the circle C_1 with the center y-coordinate O_1 touches the parabola $y = px^2$ (p is a positive real number) at two points. In addition, the y-coordinates of the center of the circle C_n are O_n $(n = 2,\ 3,\ \ldots)$. Express r_n and O_n by using n and p. (fig.2)

<The answer> We referred to Matsuda Yasuo (2013) 's method.

$$C_n\colon x^2 + (y - O_n)^2 = r_n^2$$

A parabola: $y = px^2$ …①

The following equations from these two equations

$$\frac{y}{p} + (y - O_n)^2 = r_n^2$$

$$y^2 - \left(2O_n - \frac{1}{p}\right)y + O_n^2 - r_n^2 = 0 \quad \ldots②$$

has a multiple solution of 0 or more because C_n touches ①.

from the discriminant of ② is 0,

$$\frac{1}{p^2} - \frac{4}{p}O_n + 4r_n^2 = 0$$

$$\boldsymbol{O_n = pr_n^2 + \frac{1}{4p}}$$

Therefore, the multiple solution of ② is

$$y = pr_n^2 - \frac{1}{4p} \quad \ldots③$$

$$\boldsymbol{r_n \geq \frac{1}{2p}} \ \ldots④ \text{ from } p \neq 0 \ , \ r_n > 0, \ \ y \geq 0$$

Also, substituting ③ into ①,

$$x^2 = r_n^2 - \frac{1}{4p^2}$$

$$x = \pm\sqrt{r_n^2 - \frac{1}{4p^2}}$$

Therefore, ① and C_n are touched by a point $\left(\pm\sqrt{r_n^2 - \frac{1}{4p^2}} \ , \ pr_n^2 - \frac{1}{4p}\right)$ at ④.

Since C_n and C_{n+1} are circumscribed,

$$O_{n+1} - O_n = r_n + r_{n+1}$$

$$\left(pr_{n+1}^2 + \frac{1}{4p}\right) - \left(pr_n^2 + \frac{1}{4p}\right) = r_n + r_{n+1}$$

$$r_{n+1} - r_n = \frac{1}{p}$$

Therefore, the sequence $\{r_n\}$ is an arithmetic sequence of the first term r_1 and the tolerance $\frac{1}{p}$.

[2] After the Revision

Let the sequences $\{a_n\}$, $\{b_n\}$ as follows:

$$a_1 = b_1 = s, \ a_{n+1} = qa_n - rb_n, \ \ b_{n+1} = ra_n + qb_n \ \ (n = 1, 2, 3 \cdots)$$

However, *q*, *r* and *s* are positive real numbers.

(1)~(3)The same as the original ones.

(4) Let S_n be the area of the region filled by T_n on the complex number plane. Find S_n.

<The answer> We referred to Chart Institute (2020) 's method.

$$z_{n+1} = (qa_n - rb_n) + (ra_n + qb_n)i$$

$$= (q + ri)z_n$$

$$\boldsymbol{w = q + ri}, \ \boldsymbol{|w| = \sqrt{q^2 + r^2}}$$

(1) $$w = \sqrt{q^2 + r^2}(\cos\theta + i\sin\theta) \ (\theta = \arg w)$$

When $0 < |w| < 1, 1 < |w|$, point z_n rotates by θ, centering on the point z_{n+1} and $\sqrt{q^2 + r^2}$ doubles the distance from the origin. When $|w| = 1$, the point z_n is the point that rotates by the number of θ around the origin of the point 0.

(2) $$z_1 = s + si = s(1 + i) = \sqrt{2}s\left(\cos\frac{\pi}{4} + i\sin\frac{\pi}{4}\right)$$

In addition, from de Moabre's theorem,

$$w^{n-1} = \left(\sqrt{q^2 + r^2}\right)^{n-1}\{\cos(n-1)\theta + i\sin(n-1)\theta\}$$

From $z_{n+1} = wz_n$, the sequence $\{z_n\}$ is the geometric sequence of the first term z_1 and the common ratio w,

$$z_n = z_1 w^{n-1}$$

$$\boldsymbol{a_n = \sqrt{2}s\left(\sqrt{q^2+r^2}\right)^{n-1} cos\left\{\frac{\pi}{4}+(n-1)\theta\right\}}$$

$$\boldsymbol{b_n = \sqrt{2}s\left(\sqrt{q^2+r^2}\right)^{n-1} sin\left\{\frac{\pi}{4}+(n-1)\theta\right\}}$$

(3) Point 0 is the origin O, and $P_n(z_n)$.

<i> When $0 < |w| < 1$ or $1 < |w|$,

$\triangle P_n O P_{n+1} \sim \triangle P_{n+1} O P_{n+2}$ (two-sided angle phase, etc.)

$$S_n : S_{n+1} = 1 : (q^2+r^2) \Leftrightarrow S_{n+1} = (q^2+r^2) S_n$$

Therefore, the sequence $\{S_n\}$ is geometric sequence of the first term S_1, and the common ratio q^2+r^2.

$$\boldsymbol{S_n = \frac{1}{2}|z_1||z_2| \sin\theta \cdot (q^2+r^2)^{n-1} = s^2(q^2+r^2)^{n-\frac{1}{2}} \sin\theta}$$

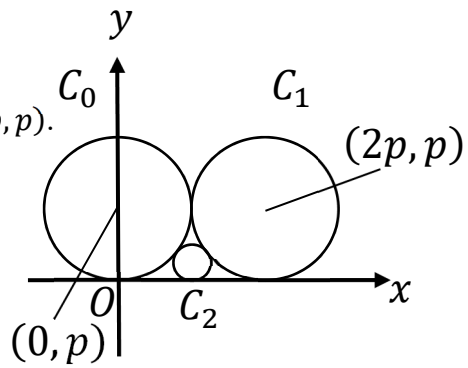
<ii> When $|w| = 1$,

$\triangle P_n O P_{n+1} \equiv \triangle P_{n+1} O P_{n+2}$ (two-sided angle phase, etc.),

$$\boldsymbol{S_n = S_1 = \sqrt{q^2+r^2}\sin\theta}$$

[3] After the Revision

Let the circle C_n as follows. First, C_0 is a circle of radius p centered on $(0, p)(p > 0)$ and C_1 is a circle of radius p centered on $(2p, p)$. Next, the circle that borders C_0 and C_1 and touches the x axis is C_2. In addition, C_n is the circle that borders C_0 and C_1 in order and touches the x axis, but C_n is not C_{n-2} $(n = 3,4,5\cdots)$. When you use (a_n, b_n) as the coordinates of the center of C_n, answer the following question. The following questions are the same as the original ones. (fig.3)



(fig.3)

<The Answer>

(1) Since the distance between the center of C_0 and C_n is equal to the sum of the radiuses of C_0 and C_n,

$$(a_n - 0)^2 + (b_n - p)^2 = (b_n + p)^2$$

$$\boldsymbol{b_n = \frac{(a_n)^2}{4p}}$$

(2) Since the distance between the center of C_n and C_{n-1} is equal to the sum of the radiuses of C_n and C_{n-1},

$$(a_n - a_{n-1})^2 + (b_n - b_{n-1})^2 = (b_n + b_{n-1})^2$$

$$(a_n - a_{n-1})^2 = 4b_n b_{n-1}$$

Since $b_n = \frac{(a_n)^2}{4p}$, $(a_n - a_{n-1})^2 = \frac{1}{4p^2}(a_n)^2(a_{n-1})^2$

Since a_n is a monotony decrease approaching the origin,

$$a_n - a_{n-1} = -\frac{1}{2p}a_n a_{n-1} \cdots (\mathrm{A})$$

By taking the inverse of both sides of (A),

$$\frac{1}{a_n} - \frac{1}{a_{n-1}} = \frac{1}{2p} \qquad (a_n \neq 0)$$

Therefore, the sequence $\left\{\frac{1}{a_n}\right\}$ is an arithmetic sequence of the first term $a_1 = \frac{1}{2p}$ and the tolerance $\frac{1}{2p}$.

$$\frac{1}{a_n} = \frac{1}{2p} + (n-1)\frac{1}{2p} = \frac{n}{2p}$$

By taking the inverse of both sides, $\boldsymbol{a_n = \frac{2p}{n}}$

4. Discussion:

As a result of generalizing [1] by revising it, it was found that an arithmetic sequence appeared in the radius of the circle. It is thought that the reason why the arithmetic sequence appears is that we used the sum relation of (two circles of radius r_n, r_{n+1}) $\Leftrightarrow$ (Distance between the center of the two circles)= $r_n + r_{n+1} \cdots$ ※. The tolerance of this arithmetic sequence is the inverse of p, which is the coefficient of x^2 in the expression of the parabola. That is, the tolerance is inversely proportional to p. Equation ④ in the answer is a condition for the radius of the circle when it touches the parabola. About all of the natural numbers n, since (tolerance)>0, $r_n < r_{n+1}$ exisits. Therefore, if the first term r_1 satisfies equation ④, r_n satisfies equation ④ for all natural numbers n. The opposite clearly exisits. When r_1 meets the equal sign of equation ④, the circle C_1 touches the parabola and the origin at a single point. In the actual entrance examination question, it is set as $r_1 = 1$, $p = 1$, and it becomes $r_n = n$.

According to Matsuda Yasuo (2020), as with the parabola in this study, when C_n and $C_{n+1}(n = 1,2,3, \ldots)$, bordering the hyperbola, are circumscribed from each other, it is found that every other Fibonacci and Luca sequence appears in the radius of the circles. In the case of hyperbola, it is considered that these differences were made by the fact that the 3-term recurrence formula appeared when using the relationship of ※.

As a result of generalizing [2] by revising it, it was found that an geometric sequence appeared in the area of the triangle. It is thought that the reason why the geometric sequence appears is that it uses the relation of the product of the similarity of the triangle. However, when $|w| = 1$, a congruent triangle

appears, which corresponds to the geometric sequence of the public ratio 1. Looking at the equation obtained by generalization, it can be seen that *p, q, r, s*, is set so that θ becomes a prominent angle in the actual entrance examination. When w is π/n $(n = 3,4,5, \ldots)$, P_{2n+1} is on a semi-straight line OP_1. At this time, it is thought that the curve appears if it is $n \to \infty$.

As a result of generalizing [3] by revising it, it was found that a harmonic sequence appears in the value of the x-coordinate in the center of the circle. The harmony number sequence appeared because the arithmetic sequence appeared when the inverse of both sides of the expression obtained using the relation of ※ was taken. In addition, from the setting of the problem, it is $a_n \to 0$ when $n \to \infty$, and the general term of the harmonic sequence converges to 0, so it is considered reasonable that the harmonic sequence appears from this point of view.

From the above results regrading the university entrance examination, the problems of several sequences and figures were fused, and generalized. Also, the meaning of three basic number sequences figures learned in high school mathematics such as arithmetic sequence, geometric sequence, and harmonic sequence was found. Therefore, there is a close relationship between the operation to be performed (the graphic meaning to be used) and several sequences, and the sequences that appear may change depending on the nature of attention even in the same problem.

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Environmentally friendly power generation

~floor power generation~

Researchers Shioiri Ayaka
Terashima Hanaka
Tsukada Naoki
Takizawa Hibiki
Ikeuchi Yuya
Teacher Fukusima Tetsuo

1. Research outline and purpose

We turned our attention to the field of power generation and become interested in piezoelectric elements(Hereinafter,this is referred to as “piezo element”) as an environmentally friendly power generation method. A piezo element is an electronic component that generates a voltage when pressure is applied.By using this property,we thought that by installing piezo elements on the floor of the school,it would be possible to effectively utilize the energy that is normally wasted.

Therefore,we decided to first investigate the pressure at which piezo element is stepped on,measure the amount of power generation under that pressure and various conditions and investigate how much power generation can be expected.

2. The way of research

・About element

The basic structure is a piezoelectric element which is sandwiched between two electrodes.The element has a piezoelectric effect.The effect happens when charge in piezoelectric body move by pressing and it has a positive charge on one side and a negative charge on the other side.

・The task

How much power can be generated when piezo elements are spread in the corridor.

・The condition

The power voltage is calculated by the maximum value measured by using the tester.(The length of corridor is assumed to be 34.5m)

1. Connect the piezo element to the tester, step on it, and calculate the average value of voltage and current.

2. Research the case of connecting in parallel and series.

3. Calculate the amount of power generated by making a round trip down a corridor.

3. Results

Research 1: the voltage of piezo element (unit: v)

	A	B	C	D
First	１５.０６	１３.０７	１０.８９	１２.００
Second	１５.７５	１２.５７	１０.４６	１２.８２
Third	１２.８７	１１.７６	９.４６	１１.１５
Fourth	１３.４８	１１.３１	９.９６	１１.８６
Fifth	１７.６２	１４.１７	１０.４５	１２.９７
Average	１４.９６	１３.１８	１０.２４	１２.１６

Average 12.63v

Research 2: the electric current of piezo element (unit: μA)

	A	B	C	D
First	２.１	１.６	２.１	２.８
Second	２.０	１.６	２.４	２.５
Third	１.４	１.５	２.７	３.０
Fourth	３.８	１.１	１.９	４.９
Fifth	４.４	１.４	２.０.	５.５
Average	２.７４	１.４４	２.２２	３，７４

Average：2.54μA

Research 3: when two piezo elements are connected in series (unit: v)

	A	B	C	D
First	２０.０	１８.４	１７.２	１７.２５
Second	１８.０	１８.７	１７.０	１２.９８
Third	１７.９	１７.１	１５.０	１４.８７
Fourth	２０.１	２２.２	１８.０	１３.６８
Fifth	２２.６	１６.６	１９.０	１７.８０
Average	１９.７２	１８.６	１７.２４	１５.３２

Average: 17.7v

・We thought it would be doubled compared to research 1, but it didn't.

・Conceivable reasons are poor connection between the piezo elements and dispersion of pressure caused by the use of two piezo elements.

【　Electric power (w) = Electric current(A) ×Voltage(V)　】

From this formula, it turned out that the electric power generated by one piezo element is 3.2×10^{-5}W

・Inspection

How much power can you get when you make one round trip down the corridor.? Calculate from the measured length of the corridor and the stride length of high school students.

→Amount of power generated: $3.2\times10^{-5}\mathrm{W}\times93\fallingdotseq2.98\times10^{-3}\mathrm{W}$

・Consideration

This time, it is assumed that one piezo element is stepped on in one step. Experiment 2 shows that it is difficult to increase the amount of electricity even if it is connected in series.

・Summary

It is difficult to generate enough electricity for piezo elements. If we use a capacitor to store electricity for long time, we may have obtained enough electricity.

4. References

Picture：https://yahoo.jp/MzBaMW

school health statistic in H29
https://www.mext.go.jp/component/b_menu/other/__icsFiles/afieldfile/2018/03/26/1399281_01_1.pdf

A measure of stride：https://www.faq.healthcare.omron.co.jp/faq/show/4195?site_domain=jp

The better conditions in charging static electricity on Kelven generator.
～There is an optimum number of coil turns～

Physics group No,4: Hiyori Hatayama/Mizuki Simasaki/
Remu Miyairi/Aoi Nakasone/Masaki Kubota/
Teacher: Mr.Ryousuke Kurata/Mr.Koki Nagayama

1. Purpose

We become interested in a device called "Kelvin Generator" that can store static electricity just by dropping water through a coil. If rainwater is used, it can be used as an emergency LED power supply. Therefore, the purpose of this study is to clarify the shape of the coil that can store static electricity sufficiently.

2. Material & Methods

Figure 1 shows the static electricity stored in the Kelvin generator. Figure 2 shows how water falls near coil A

Water is slightly positive or negatively charged. Suppose coil A negatively charged. The negative and positive charges attract each other by electrostatic induction. If water falls into the coil A and is positively charged, coil A is negatively charged. Since the water falls into cup A, cup A is positively charged. Since cup A is connected to coil B, cup B is also negatively charged and coil B is positively charged. In coil B the charge is opposite to that in Figure 2. Water droplet passing through coil B are negatively charged. Futhermore, since the cup B is connected to the coil A, the coil A is negatively charged. As these processes are repeated, electricity is gradually stored.

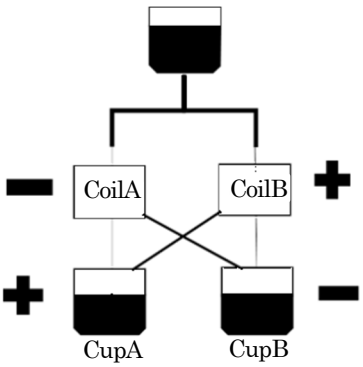


Figure 1 State that Kelvin generator is charged

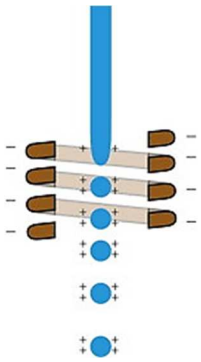


Figure 2 The situation that water pass through the coil

Based on the principle of static electricity generation, the following hypothesis was built.

> Hypothesis : More and more coil turns affect electrons and increase the amount of electrical charge .

The size of the coil part is related not only to the number of turns but also to the thickness of the coil, but the thicker the copper wire is , the more stable the coil shape will be, so fix the thickness

of the copper wire to make the coil to 1.6mm ,and conducted an experiment to test our hypothesis by changing only the number of coil turns.

3. Research method

Preliminary experiments were conducted several times based on the research method of Kelvin generator. It was found that the following points are important for stable static electricity generation.

・Water flow is not obstructed by the coils.

・Wipe water droplets scattered around the laboratory instrument when repeating experiments

・Prevent contact between coils and cups.

The contents of the experiment are as follows.

① The Kelvin generator is charged with tap water

② A foil electrostatic detector is connected to the coil part , and the charged amount is measured at an open angle of the foil

The above experiments were carried out under the following conditions.

Table 1 Conditions of experiment

The thickness of coil	1．6mm
The number of coil turns	5times, 10times, 15times, 20times
The number of measurements of each coils in 1day	2times
Experiment days	5days

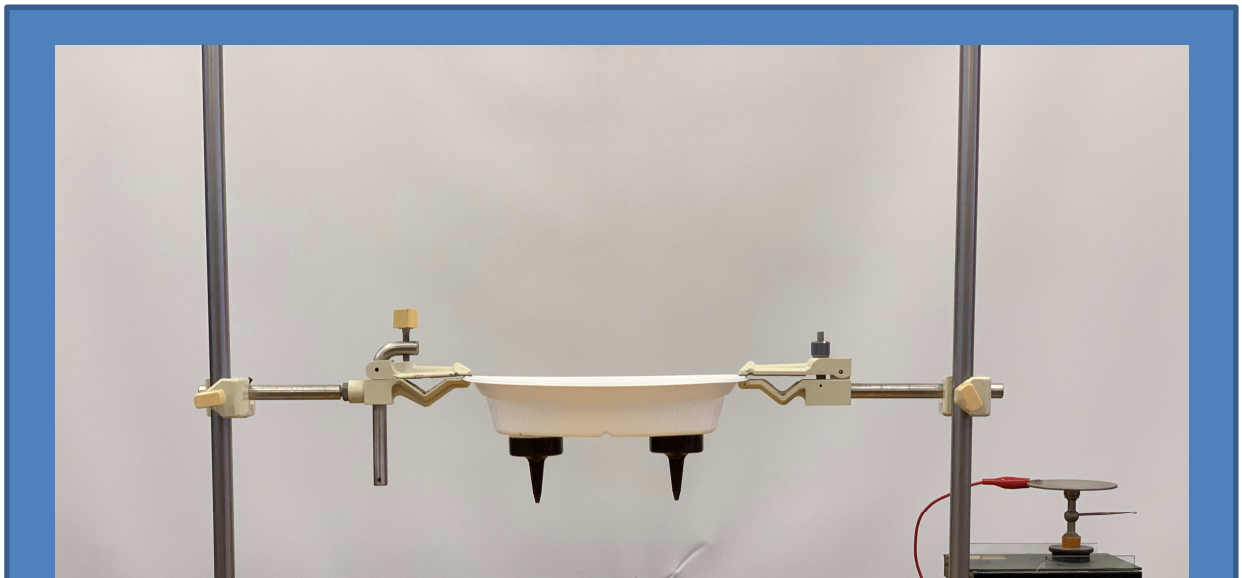


Figure 3　Kelvin generator made by us(Overall view)

4. Experimental result

Experiments were conducted twice on the same day for coils of a single winding number. In the experiment, the process are repeated for 5 days, so a total of 10 pieces of data were got.

table 2　Experimental result of coil[5]

1st	2nd	3times	4times	5times	6times	7times	8times	9times	10times
○	×	○	○	○	○	○	○	○	×
7°	×	23°	—	—	—	—	—	11	×

average angle・・・8．2°

success rate・・・8／10

Table 3 Experimental result of coil[10]

1st	2nd	3times	4times	5times	6times	7times	8times	9times	10times
○	○	○	○	○	○	○	○	○	×
20°	30°	10°	18°	22°	—	—	—	20°	×

average angle・・・17.1°

success rate・・・9/10

Table 4　Experimental result of coil[15]

1st	2nd	3times	4times	5times	6times	7times	8times	9times	10times
○	○	○	○	×	×	○	○	○	○
9°	17°	8°	70°	×	×	4°	—	—	—

average angle・・・15.4°

success rate・・・8/10

Table 5　Experimental result of coil[20]

1st	2nd	3times	4times	5times	6times	7times	8times	9times	10times
○	○	○	×	○	○	×	×	○	○
20°	7°	15°	×	11°	27°	×	×	25°	24°

average angle・・14．9°

success rate・・・7/10

The larger the amount of charge, the larger the opening angle of the coil detector.

The average value of the number of

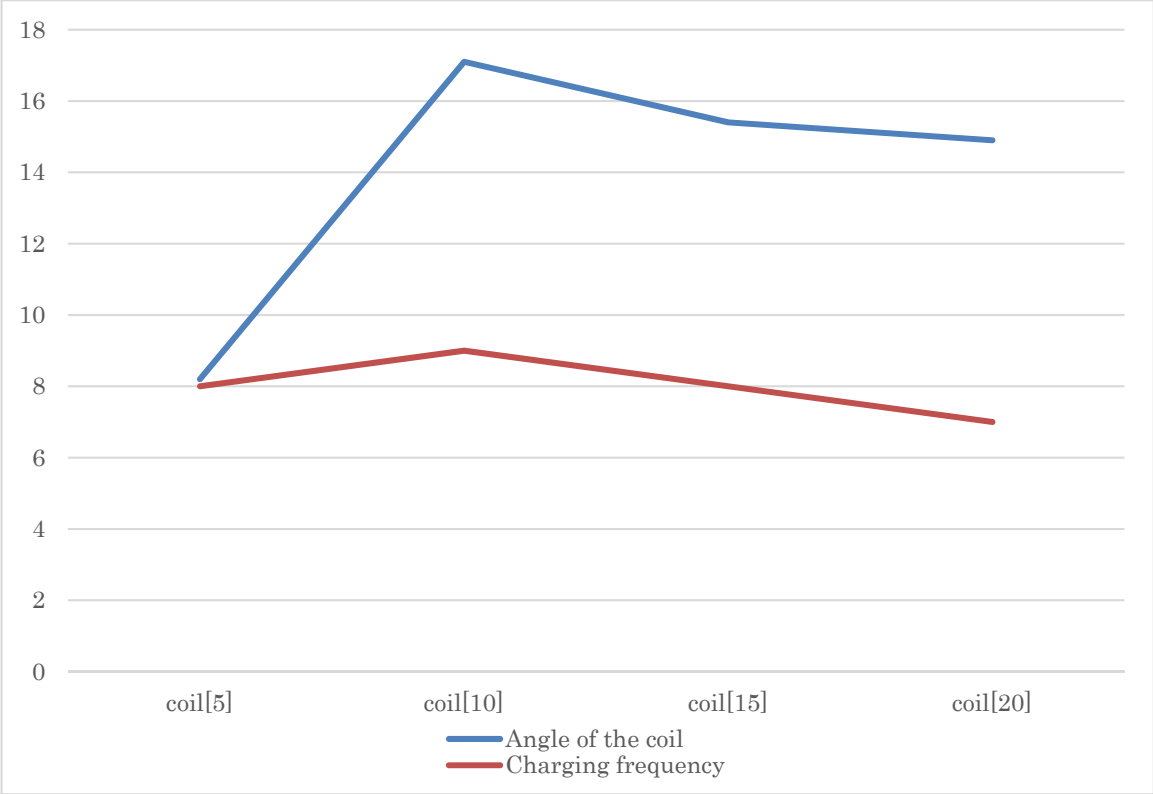


Figure 5 Relationship between the number of turns and the open angle of the foil

5.Discussion

The number of coil turns and the amount of charge are not proportional so our hypothesis is denied. The amount of coil is highest in other number of coil turns. It is expected that amount of charge is related to other factors in addition to the shape of coil part.

6. Summary

When we use a kelvin generator to store static electricity, it is necessary to maintain a strong insulation to prevent static electricity from escaping.

The amount of static electricity stored is related to the amount of water falling from the coil.

7. Future Direction of Research

Measure the change in power generation when the amount of water falling in changed.

Measure the amount of electricity charged when rainwater is used.

8. References

・Kelvin Generator http://www.gifu-nct.ac.jp/elec/habuchi/demae/Kelvin/Kelvin.html

・http://sugitani.las.u-toyama.ac.jp/physics/yoshida/2016/209s.pdf

Utilization of Dilatancy Phenomenon

～cushioning material with shock absorption～

Student name：Zen Kitazawa　Haruki Koyama
Asuma shimojo　Harune Toya
Supervisor：Mr.Kimio Miyahara

1. Purpose

The dilatancy phenomenon is a phenomenon in which liquid remains just as it is when stimulated slowly and exhibits solid-like resistance when stimulated fast. We became interested in the fact that we can make a dilatant fluid that can be either fluid or solid, only by mixing potato starch and water. Also, we learned from the preceding research that dilatant fluids have shock absorption. From this, we expected that dilatant fluids could be used as cushioning materials.

2. Materials & Method

1)Experiment 1

1.Mix starch powder and water in a ratio of 1.3:1 (starch powder 130g, water 100g) and make dilatant fluid.

2. Drop an iron ball on the mixture and measure the time until it sinks to the bottom. Repeat the process three times and calculate an average.

3. Add 1.0g starch powder and repeat the process of 2.

4. Repeat the process of 2 and 3.

2) Experiment 2

1. Mix starch powder and water in a ratio of 1.3:1 (starch powder 130g, water 100g) and make dilatant fluid.

2. Drop a rubber ball on the mixture from a height of 10 cm above the surface.

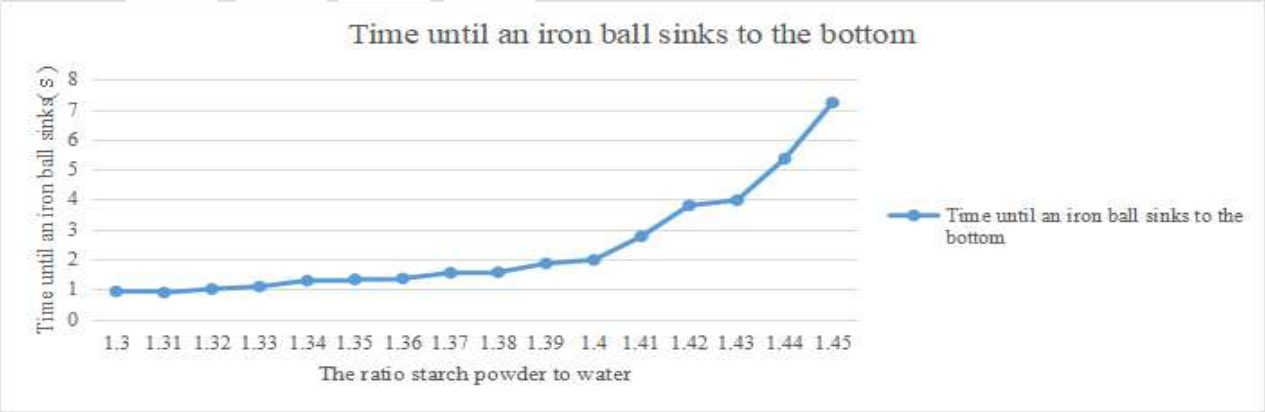
3. Heighten the point at which the ball is dropped by 10 cm and record the point at which the dropped ball bounces on the surface for the first time.

4. To increase the mass ratio of potato starch by 0.01, add 1g of potato starch and repeat the process of 2 and 3.

5. Conduct the same process as step 2 and 3 shown above, using cushioning material and water.

3. Result

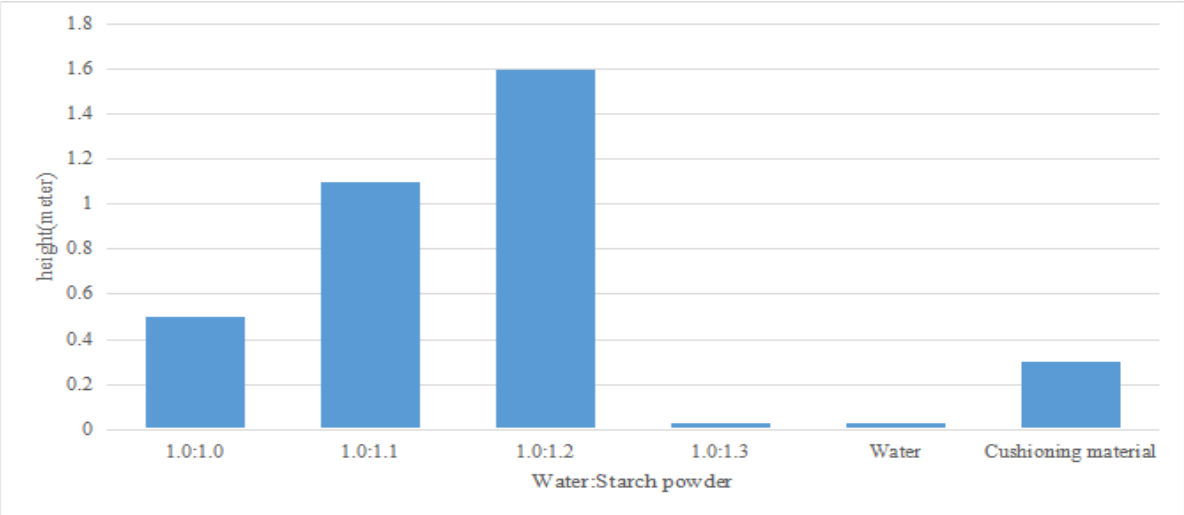
1)Experiment 1



	First	Second	Third	Averag
1. 3:1	0.87	0.96	0.96	0.93
1. 31:1	0.86	0.92	0.89	0.89
1. 32:1	0.83	1.03	1.04	0.97
1. 33:1	1.06	1.13	1.08	1.09
1. 34:1	1.48	1.04	1.36	1.29
1. 35:1	1.49	1.4	1.28	1.39
1. 36:1	1.28	1.3	1.5	1.36
1. 37:1	1.63	1.68	1.34	1.55
1. 38:1	1.65	1.46	1.67	1.59
1. 39:1	1.78	1.84	1.97	1.86
1. 40:1	2.36	1.9	1.68	1.98
1. 41:1	3.17	2.9	2.24	2.77
1. 42:1	4.95	2.88	3.58	3.8
1. 43:1	4.92	3.07	3.93	3.97
1. 44:1	7.4	3.4	5.29	5.36
1. 45:1	8.36	7.16	6.18	7.23

The table and graph above show the time until an iron ball sinks to the bottom. As the ratio of starch powder increased, the time became longer.

2) Experiment 2



The graph shows the height at which a dropped rubber ball starts bouncing. The ball bounces the highest when we use a dilatant fluid that consists of water and starch powder in a ratio of 1:1.2.

4. Discussion

First, we consider dilatant fluid composition in terms of impulse. <Equation $F\Delta t = I$> This equation shows that the value of impulse depends on Δt. The longer it takes an iron ball to sink, the smaller the value of impulse of an object is. Dilatant fluid composition increasesΔt and decreases the value because of the fluidity. When dilatant fluid remains just as it is and the ratio of potato starch increases, the fluidity begins to decrease as well as Δt, so F becomes large. However, the point at which the dropped ball begins to bounce on the surface of the mixture heightened. Therefore, dilatant fluid composition is likely to withstand momentary force.

Next, we consider dilatant fluid composition in terms of amount of work.

Dilatant fluid 200ml in a ratio of water to potato starch = 1:1.3.
W[j](amount of energy absorbed) = mgh (potential energy)
The weight of the ball = 11g
The maximum point at which the dropped ball begins to bounce on the surface = 1.6m
g(gravitational acceleration) = 9.8m/s^2
W = 11/1000×9.8×1.6÷1.7[j]
Dilatant fluid height = 0.7mm

In this case, we assumed that the energy which dilatant fluid can absorb is directly proportioned to the depth and then the value will be 0.24[l/mm]

Last, using Muzzle energy, the kinetic energy of a bullet that pops out of the muzzle, we calculated the depth of dilatant fluid which can catch the bullet. We used the smallest value, 140[j]. The depth of dilatant fluid is 140[j]÷0.24[j/mm] = 583.33..mm≒58cm. We concluded from the result that we can use dilatant fluids as cushioning materials.

5. Future Direction of Research

The energy that can be absorbed is very likely to increase like a quadratic function, although we assume it might be proportional to the depth of dilatant fluid. We learned as an example of use of dilatant fluid that bullet proof vests made from the fluid and other materials have been developed. The absorption volume of energy may be the key to utilization of dilatancy phenomenon.

6. References

https://school.gifu-net.ed.jp/ena-hs/ssh/H31ssh/sc3/31905.pdf

The cause of the color change of Shichimi Hot Spring

～Investigate the mystery of color change from green to white～

Kaya ASABA　Momoka KANAI　Yuki TAKASAKI　Haruhiro HIROKAWA

Abstract

We researched on why the color of Shichimi Hot Spring changes from green to white and asked Professor Teshima in Shinshu University to support us. We found out that it is related to sulfur colloids and that the hot spring looks white when colloids aggregate.

1. Purpose

Japan has various hot springs in the world, and each of their colors is different; for example, blue, white, yellow, and black. However, in some hot springs, the color changes differently. One of them is Shichimi Hot Spring in Takayama Village, Nagano prefecture. It is green sulfur hot spring and changes its color from green to white by its state. In the previous study, green coloring mechanism was examined, but the principle of color changing was not examined.　Therefore, we researched on the latter.

2. Materials & Methods

1) Research on why Shichimi Hot spring's color is green.

We researched on the substance responsible for green color, based on the previous study of a green sulfur hot spring.

2) Research on the cause of color change from green to white.

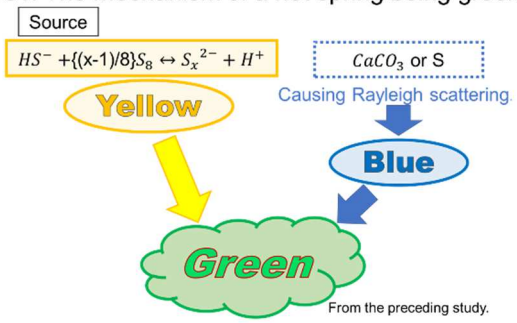
We researched on what changes the color, based on the analysis of hot spring component which was conducted by Faculty of Engineering at Shinshu University.

3. Result

1) Green coloring mechanism

According to the previous study on the mechanism of a hot spring being green, the green color is related to sulfur. Polysulfide ion which appears by reacting sulfur and Hydrogen sulfide ion look yellow. Sulfur and calcium carbonate colloids look blue because it causes Rayleigh scattering by getting a lot of sun. Then the yellow and blue color are mixed and appear as green. [Figure1]

Figure1: The mechanism of a hot spring being green.



In order to see if the cause of Shichimi Hot Spring being green is the same as the phenomenon shown above, we compare the sample of the hot spring with artificial sulfur spring which was made on the basis of the previous study above, using absorption spectrophotometry.　We found that Shichimi Hot Spring will probably have the same component and mechanism as green hot spring used in the previous study because their

shapes of the wavelength are so similar.

we also compared the color of non-filtered bath sample with its filtered sample. Filtered solution showed yellow, while non-filtered solution showed green. We think this is because the particles which causes Rayleigh scattering were removed by filtration. [Photo1,2]

Photo1: Hot spring, Not filtered.

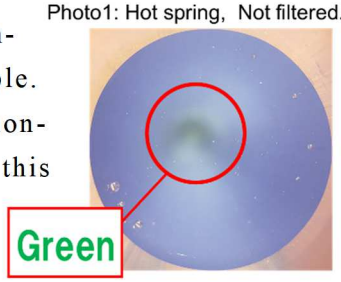


Photo2: Hot spring, Filtered.

2) The cause of color changing from green to white

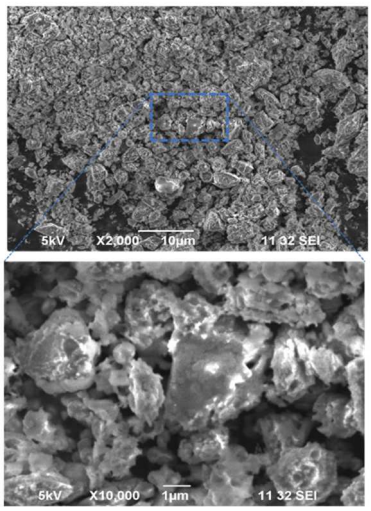
We asked Professor Katsuya Teshima, Shinshu University Faculty of Engineering Department of Material Chemistry to analyze the component of Shichimi Hot Spring.

Analysis 1: Research on the component of Shichimi Hot Spring

We researched the ion and component in the filtrate of the hot spring, using SEM, XRD and ICP-OES.

The experiment shows that almost all the elements of Shichimi Hot Spring are sulfur and calcium sulfate. From this fact, we assumed that precipitation of calcium sulfate has something to do with the white color and that the particles probably will be aggregated because they are neither electrified with positive nor negative. It is expected that small particles aggregated and get bigger and this will make the aggregated particles look white.

Photo3: SEM Filtration residue of the sample of Bath tab



Analysis 2: Analysis of the filtration residue of the bath sample

We analyzed the sample which is left on a filter when filtering the bath sample. The result shows that almost all the filtration residue is sulfur particles whose length is about from 2 to 5μm. [Photo3] We think this supports the idea that the aggregated particles of calcium sulfate look white and this leads to the white color of the hot spring.

4. Discussion

The green color of Shichimi Hot Spring comes from yellow color of polysulfide ion and blue color which occurs when Rayleigh scattering is caused by sulfur and calcium carbonate. The cause of the color changing from green to white in Shichimi Hot Spring is agglutination of sulfur particles. Because of the agglutination, the particles become larger and this can bring about the white color of the hot spring.

5. Future Direction of Research

Through this research, we found out that this mechanism will probably be true of not only Shichimi Hot Spring but also other hot springs because the cause of the white color is agglutination of sulfur particles. From this, we think that the color changing of other green

sulfur hot springs has the same mechanism as Shichimi Hot Spring. We want to research on it next time.

6. References

Coloring mechanism of green hot spring [Toho University]
http://www5.famille.ne.jp/~kunimihp/08.new.pdf
http://www.jhss.org/journal/back_number/vol60_pdf/vol60no2_119_133.pdf
Analysis chart of shichimi hot spring. [Kankyo Mirai Co., Ltd.]
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7. Thanks

We would like to express our sincere gratitude to those who cooperated in this research.
*Shichimi Hot Spring. [Koyokan]
*Shinshu University Faculty of Engineering Department of Material Chemistry
Professor Katsuya Teshima, Associate Professor Fumitaka Hayashi, Assistant Professor Tetsuya Yamada, everyone belongs to his laboratory, and the people related to this research.

The water quality around Yashiro high school～To compare it 2004 with 2020 ～

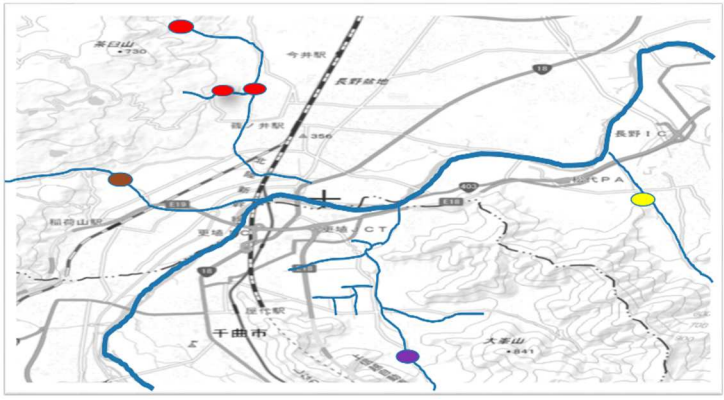
Shioiri Kazuki　Iguchi Takami　Nishimura Madoka　Haniuda Noa

Instractor Mr.Nagayama Koki

1.Purpose

The SDGs (Sustainable Development Goals) have been one of the most important issues in recent years. We believe that maintaining the water quality of rivers is one of these issues, so we decided to investigate the rivers around us. In 2004, a group of Yashiro High School students investigated the water quality of nine rivers around Yashiro High School using a river water survey set (hereafter referred to as a pack test) and indicator organisms. We selected of four of these rivers and surveyed them using the same method as 16 years ago, with the aim of comparing the results with the past and, if necessary, suggesting ways to improve the water quality of the surrounding rivers.

2.Method



Method 1

The water quality of the four rivers surveyed 16 years ago, namely, the Sawayama River, the Hijiri River, the Kanda River and the Okada River, was surveyed from August 3 to 14 according to the following steps, based on three documents: “Census manual in waterside of rivers” Let’s investigate the creature in rivers and Aquatic insects in Shiga. The methods and procedures were as follows.

① Find out the location of the river where the survey can be conducted safely.

② Record the air temperature, water temperature, river width, current speed, water depth, other bank conditions, vegetation, and the surrounding environment at the site.

③ Survey of indicator organisms

Four participants enter the river for 10 minutes and collect organisms from under the stones and on the river bottom by hand or with a net. Afterwards, identify the species of organisms collected and judge the water quality on four levels based on the indicator organisms.

④ Pack Test

Using the River Water Survey Set (Kyoeisha), measure the values of NH_4^+, NO_2^-, NO_3^-, PO_4^{3-}, and COD.

The water quality was judged based on these results.

Method 2

Workers for Nagano City Government have researched a lot of rivers by using Pack Test. Using this data, we make the graphs and compare it to our data.

Method 3

In order to research the relation between water quality of rivers and sewage system. We compare the past situation

of sewage maintenance with present situation using Sewage System Annual Report announced by Nagano City Sewage Bureau, we compare the past situation of sewage maintenance and now.

3, Result

Method 1 ③

We summed up the result of our research by using indicator organism (Table1). The number in parentheses shows how clean the water that organisms live in is. (Ⅰ) means the water is very clean. (Ⅳ) means the water is the dirtiest. As a result, we estimated Sawayama River at (Ⅰ) in 2004 and 2020. We could find organisms that live in very clean water. In Hijiri River, we found organisms that live in dirty water (Ⅲ) in 2004, but in 2020, we found organism that live in clean water (Ⅱ). In Kanda River, we found organism that live in the dirtiest water (Ⅳ) in 2004, but in 2020, we could find organism that live in the cleanest water (Ⅰ).This is the biggest change. In Okada River, we found organism that live in the dirtiest water (Ⅳ) in 2004. In 2020, the grass grew so high that we could not find the proper place to investigate, but we found very stagnant water.

Table1

Sawayama River	2004	Dobsonfly(Ⅰ) Plecoptera(Ⅰ) Fresh water crab(Ⅰ)	(Ⅰ)
	2020	Ephemeroptera(Ⅰ) Blackfly(Ⅰ) Mcrostemum radiatum(Ⅱ)	(Ⅰ)
Hijiri River	2004	Ephemeroptera(Ⅰ) Black snail(Ⅱ) Hirudinean(Ⅲ) Asellus hilgendorfii(Ⅲ)	(Ⅲ)
	2020	Plecoptera(Ⅰ) Blackfly(Ⅰ) Cheumatopsyche(Ⅱ)	(Ⅰ)～(Ⅱ)
Kanda River	2004	Asellus hilgendorfii(Ⅲ) Crayfish(Ⅳ)	(Ⅳ)
	2020	Plecoptera(Ⅰ) Ephemeroptera(Ⅰ) Gammaridea(Ⅰ) Blackfly(Ⅰ) Fresh water crab(Ⅰ) Cheumatopsyche(Ⅱ)	(Ⅰ)
Okada River	2004	Asellus hilgendorfii(Ⅲ) Crayfish(Ⅳ)	(Ⅲ)
	2020	none	

Method 1 ④

We compare the judgment of research using Pack Test in 2020 with the judgment to the judgment in 2004. However, the report in 2004 said that a = clean, b = slightly clean, c = dirty, but the specific values and correspondence table of the Pack Test were not shown. We looked at the criteria commonly used in a lot of water quality researches and made this correspondence table (Table 2). We assumed the results of our survey in 2004 did not deviate significantly from this criteria and compared the results. (Table 3) From the result of Table3, we could see that Sawaysma River and Hijiri River have not changed much compared to 2004 and were in a clean state. The water quality of Kanda River has improved from c to a. On the other hand, in Okada River, there was no change and it remained dirty. In particular, ammonia and COD values were very high in the middle stream area.

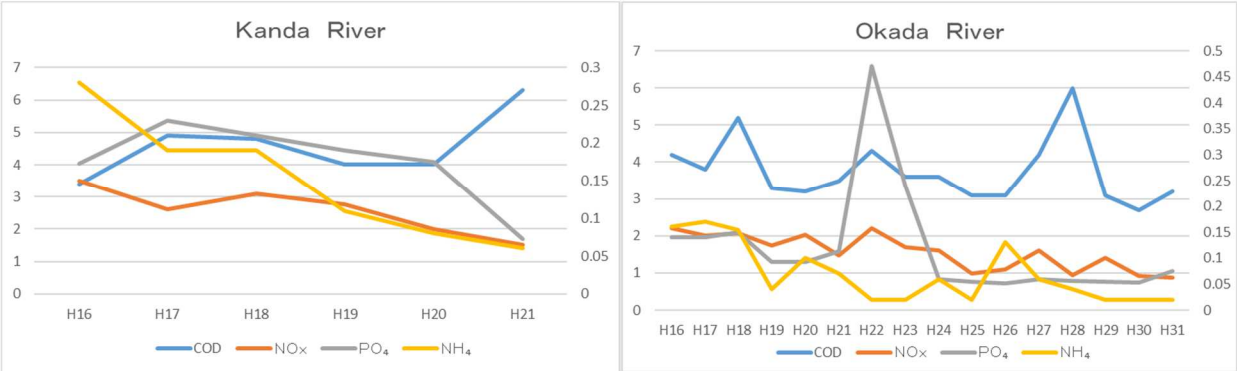
Table 2 ; the values of survey using Pack Test and correspondence table (mg/L)

	a clear	b a little dirty	c dirty
NH_4^+	～0.2	～2	2～
NO_2^-	0.02	～0.2	0.2～
NO_3^-	1	～2	2～
PO_4^{2-}	0.05	～0.2	0.2～
COD	～2	～5	5～

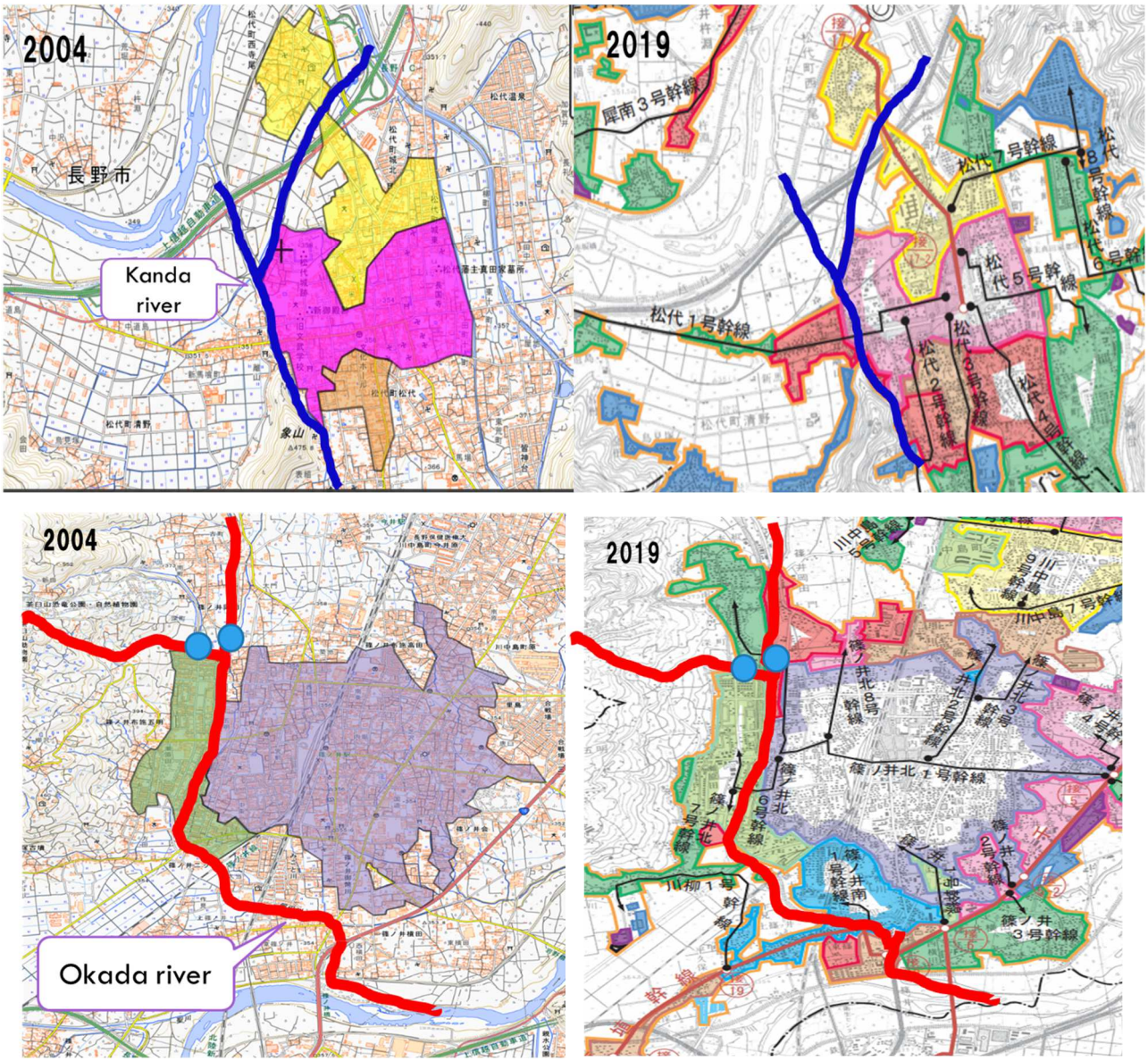
Table 3 To compare 2018 with 2004

		NH_4^+	NO_3^-	PO_4^{3-}	COD	Gross
Sawayama river	2004	a	a	b	b	a～b
	2020	a(0.2)	a(0.5)	a(0.02)	b(2～4)	a
Hijiri river	2004	a	b	a	a	a
	2020	a(0.2)	a(0.2)	b(0.1)	b(2～4)	a～b
Kanda river	2004	c	c	c	c	c
	2020	a(0.2)	a(0.5)	b(0.1)	a(2)	a
Okada river in front of shinonoi-jym	2004	a	b	c	b	b
	2020	c(2～5)	a(0.2)	a(0.05)	c(8)	b
Okada river in front of chausuyama park	2020	b(0.5)	a(0.2)	b(0.1)	c(8)	b
Okada river up stream	2020	b(0.5)	a(0.2)	b(0.2)	b(4)	b

As we got the data which Nagano City Government researched, we compared them with our data.We examined Kanda River, whose change is the largest among the rivers which we researched and Okada River, which is the worst water quality (figure 2)



As a result of the data which Nagano City government researched, both two river's water quality of both rivers is being improved. In terms of Kanda River, there are no data after 2010. However, our data refer the water quality has improved. We focused on the state of the river sewage system by means of finding out what caused it and made maps to compare past and present situation in 2004 with 2019. We arranged their size and direction to compare directly. (figure3,4)　The thick lines show the rivers. The colored areas are the area equipped sewages systems In both rivers, it can be seem that the scope of sewage system is expanding.



4. Discussion

As a result of the research of using indicator organism, the three rivers have very clean water now. Especially Kanda River has been greatly changed from very dirty to very clear. As a result of Pack Test, both Sawayama River and Hijiri River have small change, Kanda River becomes clear and Okada River remains dirty (table 3). However, referred by the data of Nagano City Government, the water qualities are both improved. (figure 2)

We focus on Kanda River and Okada River. The change of water quality of Kanda River is the biggest in the rivers which we researched. The water quality of Okada River is the worst in them. It is thought that as for Okada River the cause of difference between our data of NH_4^+ and COD, and those of Nagano City Government is difference of locations where the researches were conducted. Nagano City Government researched at downstream area and near the Chikuma River. In contrast, we researched at upstream area and middle stream area. In addition, when we researched, due to the heavy rain caused by the typhone, a dam at the upstream area was filled with sand and it was being removed which meant water quality was getting worse. To equip sewage in upstream area and middle area has not progressed. It might allow sewage from farmland and house to flow to rivers.

The area around both rivers was poorly developed sewage distinct in 2004. We think qater quality may have changed due to sewage maintenance. Figures 3 and 4 show that the sewerage systems in the areas surrounding the

two rivers have been expanded. Therefore, it can be said that the water quality has improved due to the improvement of sewage systems. However, when comparing the two rivers, the improvement in the Kanda River is more remarkable. We were able to interview Mr. Yoshitaka Matsumoto, Chairman of the River Protection Association, to find out the reasons.In the Kanda River, activities are underway to preserve the river's water quality.

・Bi-annual cleanup activities involving 17,000 residents of the Matsushiro area.
・Cleaning up the waterways in the rice fields improves the quality of the water that flows into the river.
・In order to manage the river, we collect 100 yen per household.

(Information provided by Mr. Yoshitaka Matsumoto, Chairman of the Protection Society)

5. Future Prospects

In the future, we would like to conduct pack tests before and after the inflow point of the Okada River to find out the cause of the deterioration of water quality and propose measures to improve it. In doing so, we would like to refer to the successful example of water quality improvement in the Kanda River.

6. Acknowledgement

We would like to express our deepest gratitude to the people of Nagano City Hall, the Matsusiro River Protection Association, the local community, and our professors for their cooperation in this research.

7. References

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3．滋賀の水生昆虫・図解ハンドブック　（滋賀県小中学校教育研究会理科部会）
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Changes in polyp growth rate

～Impact of dissolved oxygen and other factors～

Researcher Arai Yoshiya Takayama Aoi Takeda Narumi Hatori Kentaro Yamamoto Kurumi

Teacher Todoroki Katsuhisa

1．1.Research outline and purpose

In recent summer, news of outbreaks of jellyfish is often reported. In addition, the red tide caused by the outflow of domestic wastewater and agricultural wastewater into seawater and the nutrition has become a problem. Many marine organisms die due to eutrophication, but jellyfish are known to have huge outbreak. Therefore, we focused on the fact that eutrophication reduced the amount of dissolved oxygen in seawater. We researched how much larvae of jellyfish could tolerate a decrease in dissolved oxygen and why outbreaks occurred. From this research, we would like to utilize the data as a new index of the underwater environment where jellyfish can live.

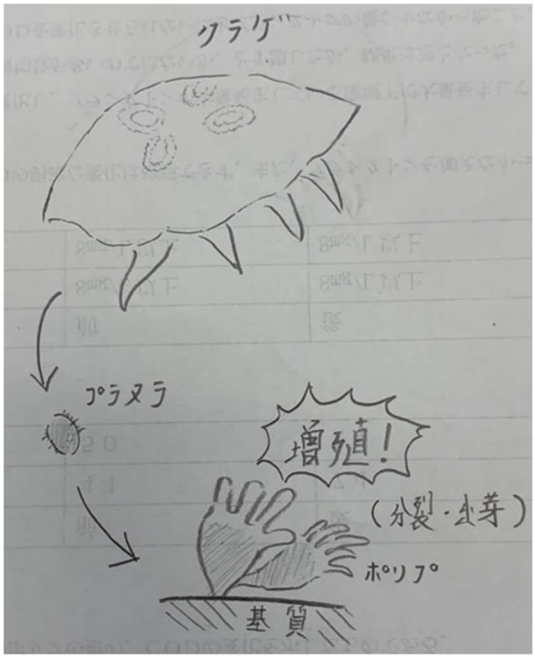


chart 1

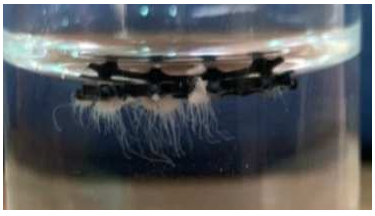
2．Research content and method

For the experiment, we used polyps of moon jellyfish, whose outbreak was reported in Japanese territorial water in recent years and is easy to obtain and breed.

As a preparatory experiment, polyps were observed for one month under four different environments. Artificial seawater (MARINE ART SF-1) was used as the breeding liquid. The environmental conditions are as follows.

(1)Temperature２０℃ in the light

(2)Temperature２０℃ in the dark



(3)Temperature５℃ in the light

(4)Temperature５℃ in the dark

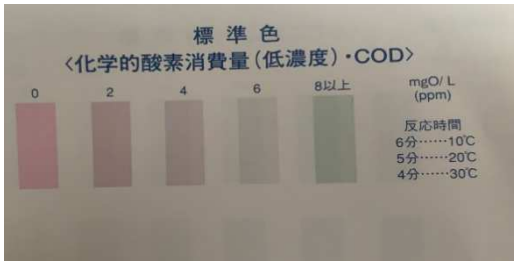
As a result of the experiment above, it was found that a room temperature of 20° C. is suitable for the growth of polyps. For this reason, we decided that the experiments should be performed from now on would be carried out in an incubator kept at a temperature of 20° C.

In the following experiments, zooplankton is used to reduce the amount of dissolved oxygen.

Experiment 1: Prepare a beaker containing artificial seawater containing almost no zooplankton and a beaker containing artificial seawater containing 3.0 ml/L of zooplankton, and prepare 44 and 50 polyps for each of the two types of beakers. Put the polyps fixed on the 4 cm square net, observe while feeding them in the incubator for 2 weeks, and use the pack test before and after the experiment to see the changes in the COD (chemical oxygen demand) and the number of polyps in the seawater was measured.

＊COD: It is one of the typical indicators of water quality and is also called oxygen consumption, which is converted into the amount of oxygen. It shows the amount of oxidant consumed by reactions of oxidation by using non oxide substances contain in seawater.

Experiment 2: The plankton, which was 3.0 ml/L in Experiment 1, was included in 10.0 ml/L, and in order to increase the number of trials, two polyps were placed in two types of beakers and observed for 6 weeks. Similar to Experiment 1, a pack test was performed before and after the experiment, and changes in the number of COD and polyps were measured.



The index of pack test

3. Hypothesis

As the hypothesis of this experiment, it is assumed that the number of polyps in the beakers with plankton increased more than that in the beakers without plankton.

4. The result of experiment

The higher COD value becomes, the less dissolved oxygen there is. The table below shows the change of the number of polyps and value of COD.

The number of polyps

	Before	Later(Two weeks later)	The amount of change
Without plankton	４４	７４	＋３０
With plankton	５０	７４	＋２４

COD

	Before	Later(Two weeks later)	The amount of change
Without plankton	More than 8mg/L	More than 8mg/L	0mg/L
With plankton	More than 8mg/L	More than 8mg/L	0mg/L

The definite change of COD was not able to be confirmed and the number of increase of polyps in the beaker without plankton was larger than that in the beaker with plankton.

As there is a large outbreak of polyps under the environment where the sea is eutrophicated and there is plankton outbreak, so it was expected that the number of increase of polyps in the beaker with plankton was larger than that without plankton, but the result was the opposite.

The cause of this result was assumed that the period of experiment was too short, so we set the period 6 weeks and the amount of plankton was 10.0ml/L in the experiment 2.

The table below shows the change of the amount of polyps and value of COD.

The number of polyps

	Before	Later(six weeks later)	The amount of change
Without plankton	７４	８４	＋１０
With plankton	７４	１２３	＋４９

COD

	before	Later(six weeks later)	The amount of change
Without plankton	More than 8 mg/L	0 mg/L	More than 8 mg/L
With plankton	More than 8 mg/L	0 mg/L	More than 8 mg/L

In Experiment 2, the increment of the population of polyps in the beaker with plankton was 5 times more than that without plankton. However, a difference was not seen in the amount of change of COD. Unlike Experiment 1, the COD value was greatly decreased in both beakers.

5. Consideration

With regard to the result of this research,
although we used distilled water and artificial water which had little organic matter, the result that the value of COD (chemical oxygen demand) was more than 8mg/L is theoretically impossible. From this result, however, we found that Polyps can multiply even under too unfavorable the environment for creatures to live, such as the high value of COD and the small amount of dissolved oxygen. Also, we can think of the cause that the amount of increase was larger than the beaker which had little plankton as the much animal plankton which is fed for polyps. From Experiment 2, the fact that the COD value of decrease did

not change and the number of polyps decreased widely regardless of the number of plankton means the increase of dissolved oxygen. Since polyps or plankton are always breathing, these results are impossible. We can regard it as a fault of "Pack Test".

According to some preceding studies, polyps are growing up as they eat various kinds of plankton like copepod and ciliate. Also, they are multiplying rapidly on account of their eating plankton which increased by eutrophication and in an unfavorable situation for other creatures. On the other hand , at present , there are some unknown points. For example, the change of polyps' growing speed on each COD phases or the most suitable value of COD have not been solved. Besides it is not certain, how polyps develop under the situation which has some elements like nitrogen, phosphorus, silicon and detergents which have a bad influence on eutrophication.

6. Future prospects

As it took time to conduit control experiments and to start main experiments, and we had trouble examining the number of these experiments, considering the results of these experiments and preceding experiments, we give an account of future prospects as follows.

Divide the experiments into various phases by changing the amount of plankton, then observe the differences of polyps' growing speed, and look into the stage when polyps grow at the best speed. Also, when we measure the volume of dissolved oxygen, we are going to use a special equipment to measure dissolved oxygen. Moreover, we will research the change of polyps growing speed when we add some substances which cause eutrophication or water pollution to artificial sea water such as nitrogen phosphorus, potassium and silicon. Concretely, we put phosphate in case of phosphorus, nitrite nitrogen in case of nitrogen into the artificial seawater.

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Herbicide-Free Plant Cultivation

~Verification of weed suppression by allelopathy of hairy vetches~

Researcher　So Kubota　Mana Sakai　Saya Sugita　Miori Yoshiike
instructor　Eiko Horiuchi　Keisuke Shiohara

1. Research outline and purpose

Growing weeds are a major problem in agricultural cultivation. Weeds deprive crops of nutrients, moisture and sunlight, causing in poor yields and low quality products. For example, the commonly used herbicide contains a substance called glyphosate, which is considered to affect human bodies (prevent weight increase) and liver functions. Glyphosate does not selectively kill plants, so spreading it over a wide area affects the ecosystem around the farmland. Therefore, herbicides must be used appropriately. So we should look for ways to get rid of weeds without using the sanitizer, and we try to improve the growth of many kinds of plants.

The purpose is to confirm and propose this practicality of this method by focusing on hairy vetches (Japanese name:“ビロードクサフジ” or Vicia villosa Roth), which is said to have a controlling effect of weeds.

2. About the Hairy Vetch

Research by an institute since around 1990 has shown that the plant’s allelopathy is strong. It has the effect of inhibiting the growth of other plants. It is also a green manure plant

.

3 Research Methods

This time, a “sandwich” method is used to investigate the presence of allergens in the ground and the roots of hairy vetches (the inhibitory or stimulating effects of chemicals released by plants on other organisms).

(1) Hairy Vetch

We prepared an incubator set at 22℃ 16cm-long, 10cm-wide, 12.5cm-thick container was filled with absorbent cotton, and the seeds of the hairy vetches were germinated on top of the cotton until the top of the container was reached (about 13cm). Grown hairy vetches are divided into the terrestrial parts and roots with seeds as the boundary, and both of them are finely chopped with scissors with each about 3mm-long.

(2) Plants to be tested

Leaf lettuce (Chrysanthemum family), corn (Grass family), and Japanese mustard spinach (Brassica family)

These three kinds of plants were prepared. The germination rates were guaranteed to be over 80%, over 75%, and over 85%, respectively. The plants of the Chrysanthemum, Grass and Brassica families are abundant in the farmland, so they were chosen

.

(3) Sowing and breeding of seeds

The target plants were seeded on (2) agar culture medium. Five leaf lettuce seeds and Japanese mustard spinach seeds were sown on each petri dish and three corn seeds were so done, too. Fifteen petri dishes were placed in an incubator set at 20℃ and germinated for seven days.

4. Experimental results and considerations

Only one corn sprouted in a petri dish without hairy vetches, and none in a petri dish with hairy vetches. This is probably because the period is only one week, and the overall germination rate of corn is poor.

Japanese mustard spinach and leaf lettuce sprouted in all the petri dishes. Since there was no difference in the number of days until this germination, it is believed that hairy vetches did not inhibit the germination of Japanese mustard spinach and leaf lettuce.

On the other hand, Japanese mustard spinach and leaf lettuce in petri dishes with hairy vetches had shorter roots and buds than those without hairy vetches. Compared to the average length of leaf lettuce with no hairy vetches, the length of the bud and root in the petri dish with hairy vetches dropped by about 29% and nearly 12% on the ground. The length of Japanese mustard spinach' root in the petri dish with root hairy vetches dropped to 40%, that in the petri dish with the terrestrial hairy vetches dropped to 62 %, and the length of roots dropped to 15%. From these results, hairy vetch can be expected to inhibit plant growth. From now on, we will confirm the effect on low germination rate of corn seeds and study the properties of inhibitory substances.

What Causes the Differences in Columnar Joints?

by Yuki Enomoto, Yugo Sakurai, and Kanta Hayashibe

"Columnar joints" means hexagonal prisms made from lava. When lava touches the ground and it is rapidly cooled, the contraction of volume is caused and it changes into columnar joints. It is discovered that most of columnar joints were made of basalt, and some columnar joints are pentagonal prisms and square prisms. However, even though scientists are making progress in their studies, there is no definite answer to why there are differences in size and length between each columnar joint. We wanted to discover the answer and clarify the environmental conditions of the time such joints were formed, such as temperature and viscosity. So we conducted experiments as follows:

It is hard to do experiments using lava, so we used cornstarch as a model of columnar joints. Since a study shows that cornstarch changes like columnar joints when it is dissolved in water and water is evaporated, it is said that most of its features seen are common with columnar joints. In addition, the phenomenon of volume contraction is seen in both of them. We thought we can prove the factor causing differences between columnar joints by using cornstarch.

We prepared 8 containers, named each container A~H, put cornstarch and water in it, mixed them, and dried them.

We used two ways of drying: one uses an incubator, and the other a light bulb. The specific conditions are as follows:

	A	B	C	D
Water	70g	70g	100g	50g
Starch	30g	50g	140g	70g
Depth	shallow	shallow	deep	shallow
Way	Incubator 40℃	Incubator 40℃	Incubator 70℃	Incubator 70℃
Crack	Straight	Weblike	Non - straight Minute	Radial
Remarks	Mold grew	Mold grew	Surface peeling	The condition was the same as D

	E	F	G	H
Water	50g	50g	50g	50g
Starch	70g	70g	70g	70g
Depth	deep	shallow	deep	shallow
Way	Incubator 70℃	Incubator 70℃	**filament lamp**	**filament lamp**
Crack	Non - straight Minute	Radial	Non - straight Minute	Straight
Remarks	Surface peeling	The condition was the same as D	Surface peeling	

・Comparing C with E, we found that the form of cracks doesn't depend on the depth of containers.

・Comparing D, E and F, there are few differences between drying by incubator and a light bulb. However, comparing F and H, there are obvious differences between them.

・Comparing A with B, we found that the more cornstarch a container contains, the more complex cracks become.

From these comparisons, we supposed that the gap of ease with which the mixture of water and cornstarch in a container was warmed caused these differences. The bigger the gap, the more complex cracks become. This hypothesis fits the conventional theory, which tells that when lava touches the ground and is rapidly cooled, it changes into columnar joints.

On the other hand, though we supposed that the ease of warming relates to the differences, we found that how easily columnar joints form didn't depends on the amount of water. You know, water obviously relates to the ease of warming. As the amount of water increase, it is warmed more slowly. Moreover, although the conditions of D and F were the same, the shape of cracks were different.

We discussed these contradictions, and draw two conclusions. The first one is that in the case of lava, we don't have to consider the ease of warming because it is warmed for a long time in volcanos. The second one is that we conducted an experiment with container F during the night while the others were done during the daytime. These contradictions turned out to be trivial, so we concluded that

our hypothesis is also reliable.

In conclusion, we set up a hypothesis that whether lave become columnar joints depends on the gap of ease with which the inside and outside of it is warmed. It is still debatable, but finding the answer to it will contribute to the development of geoscience.