Risk/Benefit Anaslysis of the Regulation of Foodstuffs Contaminated with Radioactive Substances

OKA Tosihiro*

9 August, 2012

*Faculty of Economics, Fukui Prefectural University, 4-1-1 Kenjojima, Matsuoka, Eiheiji-cho, Yoshida-gun, Fukui, 910-1195 Japan. Tel: +81 776 61 6000, Fax: +81 776 61 6014. E-mail: oka@fpu.ac.jp.

Foodstuff regulation (1)

- Just after the Fukushima I nuclear accident, radioactive contamination was detected in vegetables and milk in the area far from up to 250km from the plant.
- Ministry of Health, Labor and Welfare set provisional regulation values for radioactive iodines and caesiums, and began to prohibit the distribution of milk and vegetables produced in the area where the concentrations over the regulation values were found since 21 March.

Provisional regulation values

Iodine		Caesium	
Drinking waterr	300	Drinking water	200
Milk and dairy products	300	Milk and dairy products	200
Vegetables (excluding roots and potetoes)	2000	Vegetables	500
		Crops	
		Meat, egg and fishes	

Foodstuff regulation (2)

- In July 2011, beef contamination of radioactive caesiums was found and the distribution of all the beef from Fukushima Prefecture was stopped for about 1 month.
- In October, kaki (Japanese persimmon) was found to include radioactive caesium. Although the concentration was under the regulation value, radioactive caesium was supposed to be concentrated when kaki is dried. Date region of Fukushima Prefecture is famous for producing anpo-gaki (a kind of dried kaki). Fukushima Prefectural Government requested the producers not to produce anpo-gaki.
- In November, rice contamination was detected, and the rice that had grown in the area of about 7000ha, where rice with the concentration above 100 Bq/kg was found, was excluded from food delivery.

Stricter regulation standards

- The new standard values for foodstuffs contaminated with radioactive caesium were set in March 2012, which were to be applied since April.

New standard values for radioactive caesium for foodstuffs

	(Bq/kg)
Drinking water	10
Milk and dairy products	50
Other foods	100

- The values for foods in general (100Bq/kg) is based on the criterion that no one intake radioactive caesium which causes internal dose of more than 1 mSv/y, even if half of the foodstuffs eaten by him/her are contaminated with that value.

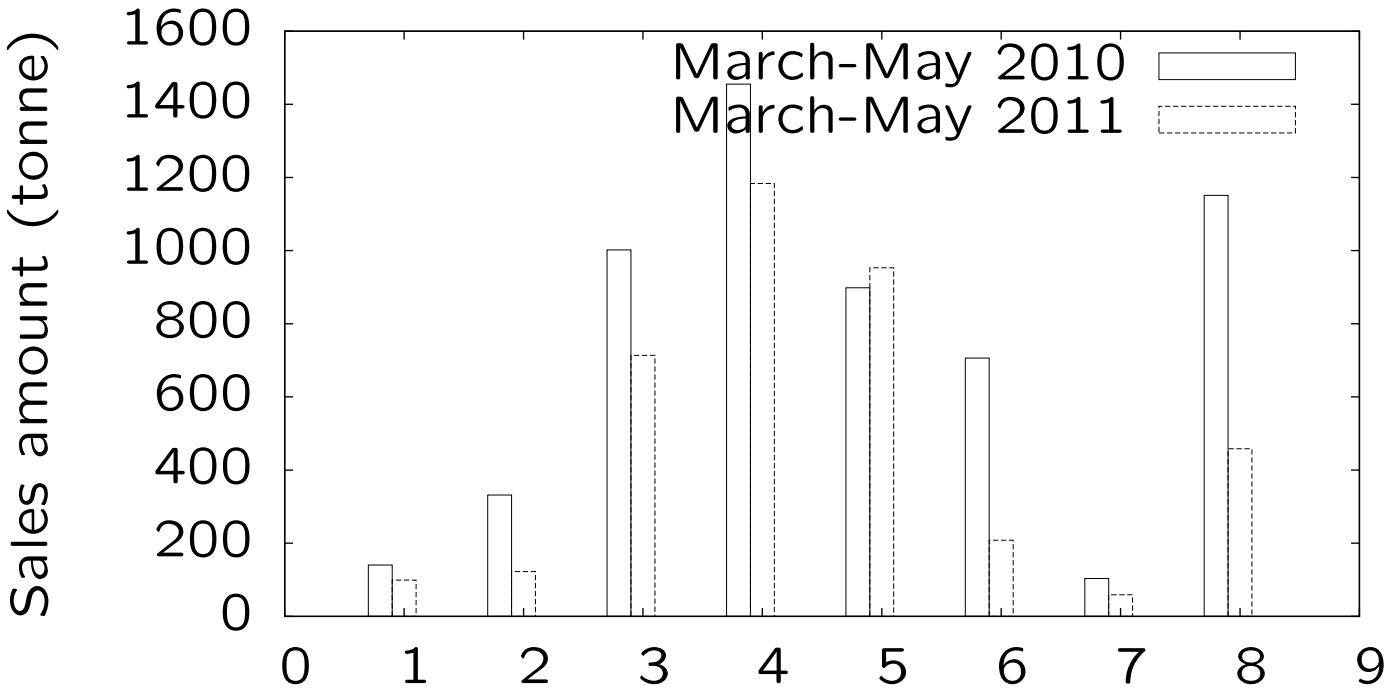
Cost per life-year saved is estimated for the regulations of:

1. Vegetables from March to May 2011
2. Beef from July to August 2011
3. Anpo-gaki in the autumn 2011
4. Rice produced in 2011

Average radiocaesium consentrations in vegetables produced in Fukushima Prefecture from March to May 2011

	March		April		May	
	No. of samples	Conc. (Bq/kg)	No. of samples	Conc. (Bq/kg)	No. of samples	Conc. (Bq/kg)
Shiitake mushroom	0	-	74	720	45	480
Crown daisy	0	-	2	38	0	-
Leek	14	28	6	12	11	10
Spring onion	3	11	3	42	3	10
Broccoli	14	3400	30	410	53	26
Spinach	25	5800	80	1200	90	29
Mizuna (potherbmustard)	2	1700	2	770	3	11
Other vegetables	54	4700	127	540	215	250
Total/Average	112	2300	324	540	420	160

Recuction in production due to the regulation of vegetables



1: shiitake mushroom, 2: crown daisy, 3: leek, 4: spring onion, 5: broccoli, 6: spinach, 7: mizuna, 8: other vegetables

Cost estimates due to the regulation of vegetables

	March			April			May		
	Prod. red. (t)	Price (yen /kg)	Cost (1000 (yen)	Prod. red. (t)	Price (yen /kg)	Cost (1000 (yen)	Prod. red. (t)	Price (yen /kg)	Cost (1000 (yen)
Shiitake	-	-	-	21	963	19957	0	-	0
Crown daisy	-	-	-	92	615	56600	28	516	14383
Leek	157	437	68448	112	462	51712	20	299	6022
Spring onion	335	330	110575	-46	304	-14045	-17	251	-4353
Broccoli	-7	226	-1553	5	339	1548	-53	277	-14541
Spinach	208	366	76263	145	628	91027	145	433	62787
Mizuna	22	451	10011	15	546	8068	7	385	2845
Others	147	694	102290	286	854	243934	260	464	120657
計	869		367588	674		472845	433		192310

*) 80 yen = 1 dollar, 100 yen = 1 euro.

Avoided radiocaesium intake

(kBq)

	March	April	May
Shiitake mushroom	-	15,000	-
Crown daisy	-	3,500	-
Leek	4,400	1,300	200
Spring onion	3,700	-	-
Broccoli	-	1,900	-
Spinach	1,200,000	180,000	4,200
Mizuna (potherbmustard)	38,000	11,000	83
Other vegetables	700,000	160,000	66,000
Total	2,000,000	370,000	70,000

Loss of life-expectancy (LLE) per mSv and per 1Bq of radiocaesium

Age	LLE	
	(day/mSv)	(day/Bq)
0	1.7	4.1×10^{-5}
0-9	1.5	1.7×10^{-5}
10-19	0.99	1.6×10^{-5}
20-34	0.59	9.5×10^{-6}
35-49	0.31	4.9×10^{-6}
50-	0.066	1.1×10^{-6}
Average	0.42	6.1×10^{-6}

1. Coefficients (mSv/Bq) are 2.4×10^{-5} for the age zero, 1.1×10^{-5} for the ages 0-9 and 1.6×10^{-5} for the other ages on the basis of ICRP(1996), Publication 72, *Annals of the ICRP*, 26(1), assuming the quantity of Cs-134 is the same as that of Cs-137 in radioactivity.
2. The model of Preston et al.(2003) was applied to the life-table and to the mortality statistics of Japan in 2009.

Cost per life-year saved (CPLYS) for the regulation of vegetables

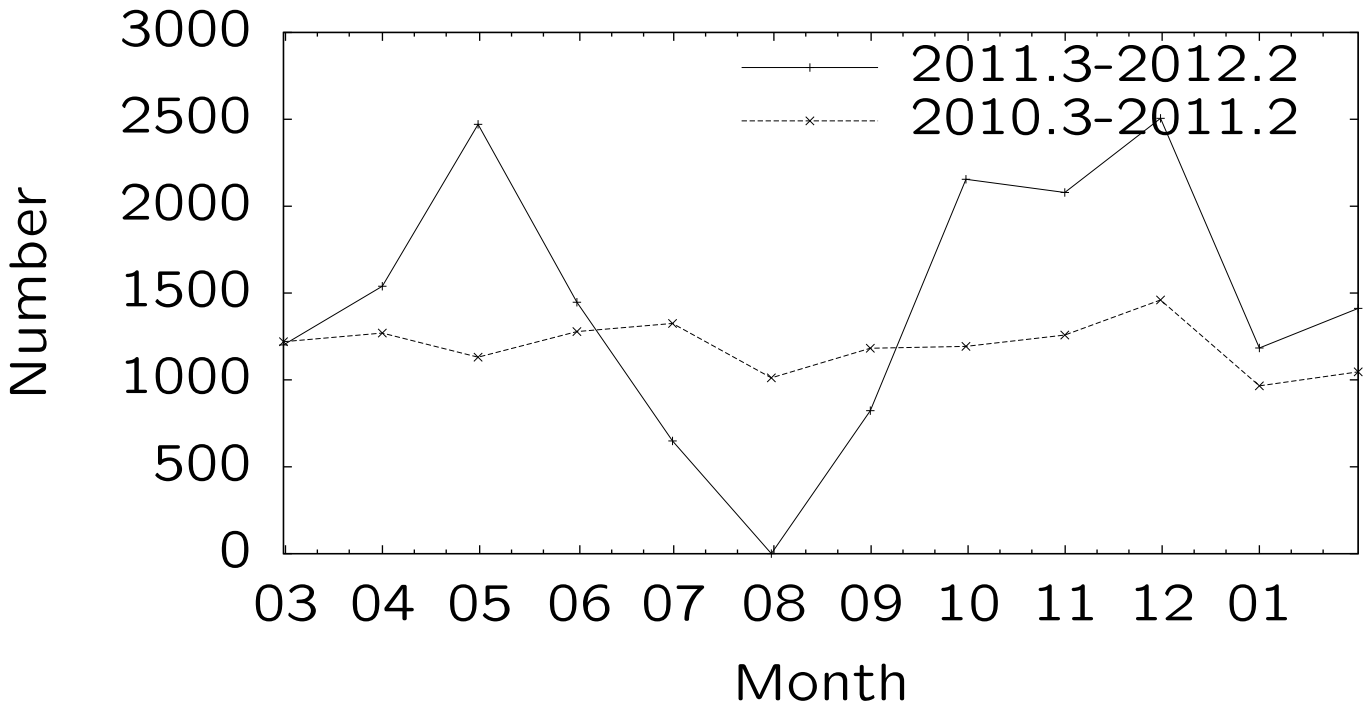
	March	April	May
Cost (million yen)	370	470	190
Life-year saved (year)	33	6.1	1.2
Cost per life-year saved (million yen)	11	77	160

*) 80 yen = 1 dollar, 100 yen = 1 euro.

Regulation of distribution of beef

- From 19 July to 25 August 2011, shipment of all the cattles raised in Fukushima Prefecture was banned.

Number of the cattles raised in Fukushima Pref. and shipped to the Tokyo beef market



Cost per life-year saved for the regulation of beef

- The costs due to the regulation of beef shipment consist of:
  1. Extra production cost due to the delay of shippment,
  2. Deterioration in quality of beef.
- The extra production cost is estimated to be 117 yen/kg.
- The cost from deterioration in quality is estimated to be 15 yen/kg.
- Although the average price of Fukushima beef was reduced to 745 yen/kg during July 2011 to February 2011 from the price in the last year, 1440 yen/kg , the most of this price reduction is supposed to be a result of reputation, and not regarded as a real cost.
- This regulation has reduced the average concentration of caesium in beef that might have been intaken from 61 Bq/kg to 40 Bq/kg, which means the reduction of LLE of 3.5×10^{-7} years/kg. As a result, the cost per life-year saved is 370 million yen.

Rice (1)

- Areas where rice with the contamination above 500 Bq/kg of radiocaesium was produced
  1. Onami district in Fukushima city

Conc. range (Bq/kg)	ND	0-100	100-500	500-
No. of samples	1980	1641	1202	283

     Average conc. is 118 Bq/kg. → Polished rice—52 Bq/kg
  2. Other districts in Fukushima city, Date city and Nihonmatsu city

Conc. range (Bq/kg)	ND	0-100	100-500	500-
No. of samples	1226	474	178	22

     Average conc. is 55 Bq/kg. → Polished rice—24 Bq/kg
- On the average, 4600 tonnes of rice with the concentration of 26 Bq/kg was withdrawn from food delivery, which reduced the intake of radiocaesium by 110 million Bq.
  →LLE reduction—1.8 years.
- The lost value of the rice is 1.1 billion yen.
  → CPLYS—600 million yen

Rice (2)

- Areas where rice with the concentration of 100-500 Bq/kg was produced

Conc. range (Bq/kg)	ND	0-100	100-500
No. of samples	6730	1632	313

  Average conc. is 36 Bq/kg. $\rightarrow$ Polished rice—16 Bq/kg
- On the average, 32,000 tonnes of rice with the concentration of 16 Bq/kg was withdrawn from food delivery, which reduced the intake of radiocaesium by 460 million Bq.
  $\rightarrow$LLE reduction—7.8 years.
- The lost value of the rice is 7.8 billion yen.
  $\rightarrow$ CPLYS—1.0 billion yen.

Anpo-gaki (dried persimmon)

- The average concentration of radiocaesium in the samples of anpo-gaki produced in Date region that were measured in October 2011 was 247.7 Bq/kg, three of the samples having the values exceeding 500 Bq/kg. The prefectural government requested to stop the production.
- The damage cost due to the stop of the production was estimated to be 2.225 billlion yen.
- It is estimated that 1924 tonnes of ampo-gaki was not produced, which has reduced the intake of radiocaesium by 477 MBq, which would have reduced the LLE by 8.0 years.
- The CPLYS is estimated to be 280 million yen.

CPLYS of the foodstuff regulations

		CPLYS (million yen)
Vegetables	March	11
	April	77
	May	160
Beef		370
Rice	500Bq/kg-	600
	100-500Bq/kg	1000
Anpo-gaki		280

CPLYS for several past regulations of toxic chemicals

Regulation	Cost per life-year saved (million yen/year-LLE)
Prohibition of chlordane	45
Mercury regulation in the caustic soda production	570
Mercyry removal from dry batteries	22
Regulation of benzene in gasoline	230
Dioxin control (emergency countermeasures)	7.9
Dioxin control (long-term countermeasures)	150

- The values for CPLYS of the regulation of the foodstuffs contaminated with radiocaesium are comparable with those for the past regulations of toxic chemicals

Value of a life-year

- WTP-based value of a statistical life (VSL) ranges from 200 to 2000 million yen for Japanese people, with the average of 800 million yen.
- The value of a life-year derived the VSL is 20 million yen. (GDP per capita is about 3.6 million yen, or 46,000 dollars)
- Compared with the value of a life-year, the values for CPLYS are much higher, except for the regulation of vegetables.
- The standard values for foods which would keep the CPLYS not to exceed the value of a life-year would be:

	Price (yen/kg)	Standard value (Bq/kg)
Vegetables	250	750
Beef	1400	4200
Rice	240	720

The second year of the accident

- In the first year, regulations are, in many cases, accompanied by disposal of agricultural products. That means high costs of regulation.
- In the second year, countermeasures in the production processes have been applied:
  - Cleaning of the bark of fruit trees,
  - Application of zeolite to rice fields, and
  - Prohibition of feeding cattles on grass containing radiocaesium of more than 100Bq/kg.
- These countermeasures are, in general, cheaper than disposing of the products, but the magnitudes of risk-reduction would also be very small, so the cost-effectiveness may remain low.
- If in spite of the countermeasures the concentrations in the products are above the stricter present standards, then the cost-effectiveness would be further reduced.